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ITT at Telecom 83

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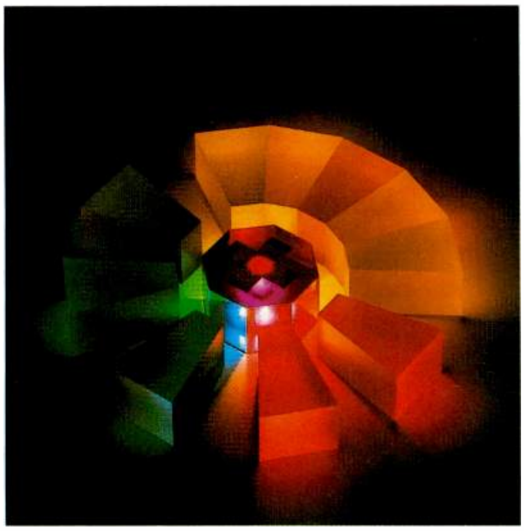


The ITU-promoted Telecom exhibitions every four years are occasions for a comprehensive display of the state of the art by the world's telecommunication industry. For Telecom 83, ITT has devoted time and resources to its corporate stand to show an unprecedented breadth of new products and services.

Overview

The ITU sponsored Telecom exhibitions and the associated economic, technical, and legal symposiums have become high points in the calendar for all those involved in the telecommunication industry – users, service providers (PTTs, Administrations, common and private carriers), and equipment suppliers. These shows, which are held every four years, increasingly mark the extraordinary advances that are taking place in the technologies on which the telecommunication industry depends. Each new Telecom exhibition clearly demonstrates continuing acceleration in technological progress. Whereas historically the telecommunication industry has often been conservative in applying new technology, today the industry is taking full advantage of new methods and is itself a prime motivator and participant in the transformation of the global telephone network.

The ITT corporate exhibit at Telecom 83 together with the stands of affiliated ITT companies, and the varied papers presented by ITT scientists at the technical symposium all reflect the Corporation's advanced technological and engineering accomplishments. Some 23 600 ITT scientists, engineers, and programmers working at 45 centers in 24 countries have been involved in forwarding the latest state of the art in all aspects of telecommunication technology. Their efforts and achievements represent an annual investment of 1.3 billion US dollars in research, development, and engineering.

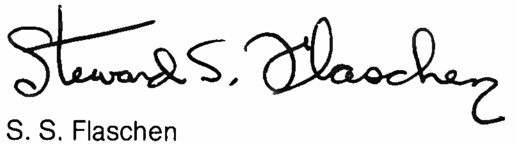
ITT's research centers are purposely located in many countries in order to be close to customers and to make it possible to cooperate with national laboratories and universities to develop new products and services, the demand for which may vary from country to country. At the same time, this approach meets national aspirations for technology transfer and local employment, a 60-year long ITT tradition.

This issue of *Electrical Communication* offers a broad view of the products and services on show and being demonstrated on the ITT corporate stand at Telecom 83 and the papers presented at the technical symposium. For the many regular readers in the 150 countries to which *Electrical Communication* is distributed, this issue will enable them to 'visit' the exhibition and become familiar with the newest technologies and products available from the Corporation. Those who are able to attend Telecom 83 will find it an invaluable and comprehensive guide to the corporate stand, and an important reference source for many years.

While a large part of this issue is devoted to describing the ITT products on the corporate stand, advantage has been taken of the occasion to present readers with a wider view of ITT's approach to developing, managing, and marketing telecommunication products and technologies. The first two articles examine ITT's use of technology in telecommunication and at the way in which these technologies are used throughout the Corporation's product range. These are followed by an article on how the ITT corporate stand was conceived and designed, including an insight into the creation of a small-scale integrated services digital network.

The third part of this issue discusses how key technologies – systems, intelligent products, programming, materials, VLSI, fiber optics, and biotechnology – are managed in ITT, with emphasis on the use of Key Technology Steering Groups. These are important tools within ITT for managing state-of-the-art technologies with the participation of affiliated research and manufacturing units worldwide. The chairmen of the steering groups, all senior ITT engineers and scientists, outline how they expect their spheres of technology to evolve beyond the next generation. A complementary series of articles from the directors of three of ITT's major European research centers describes the role research plays in developing new technologies, and how the laboratories are themselves evolving to meet the challenge of world-class technology and products. Together, these sections offer our readers an informed glimpse at the technologies and products that may be on display at Telecom 87 and Telecom 91 – and even beyond.

Now is an exciting time for the user of telecommunication and business communication systems, and for the scientists and engineers engaged in developing the new systems and technologies. Microelectronics, information theory and processing, programming, and other key technologies are converging, as mankind's total knowledge base continues to double every six years. At this time of change, ITT recognizes its role and responsibilities as a leader in the telecommunication industry. The Corporation's goal is to use its research, development, and production capabilities to provide a total system solution that meets the evolving needs of users and service providers. We believe that the many exhibits from ITT companies which are on view at Telecom 83 in Geneva reflect the Corporation's dedication to technology, quality, and the application of science for the benefit of society.



S. S. Flaschen
Senior Vice President and
General Technical Director ITT
ITT Headquarters, New York, USA

ITT Technology for Telecommunication

As a major supplier of telecommunication products and services, ITT is committed to developing and using advanced technologies to ensure that its equipment fully meets users' requirements, and to support continuing evolution of telecommunication systems.

I. A. Cermak
ITT Advanced Technology Center, Shelton, Connecticut, United States of America

Introduction

A viable, long-term vendor in the telecommunication field must continually demonstrate basic capability in and commitment to the technologies that are critical to meeting market requirements for functionality, implementation, and support. In addition, growing pressure to establish capability, self-sufficiency, and local employment within national boundaries means that a viable international vendor must establish a successful track record in all phases of technology transfer, leading to the development of manufacturing facilities in the host country.

ITT, with a long record of achievement in all these areas, has become the second largest telecommunication supplier in the world. This article focuses on ITT's capability in and commitment to the full range of relevant technologies required to enable it to meet the needs of its customers.

ITT's Commitment to Technology

Development of proprietary technology requires resource commitments that are considerable and long-term. ITT research and development investment has increased steadily, and totaled \$700 million in 1982, with more than 70% having direct relevance to telecommunication. An additional \$600 million was expended for engineering, that is, modifications and improvements to existing products to satisfy evolving customer requirements. Figure 1 shows ITT's technology network, which today includes 45 advanced engineering centers in 24 countries, employing nearly 24 000 scientists, engineers, and programmers.

ITT telecommunication products have been characterized over the years by significant innovations (Table 1), particularly in digital technology. All are significant in that they have enabled products and services to maintain corporate strength and

Figure 1
The ITT technology network.

Table 1 — Key ITT technological innovations

Flat panel (LCD) displays
Electronic subsets
Radio paging
Digital television
Speech recognition and synthesis
Fiber optics theory and application
Image intensifiers (low light television)
Microwave transmission
Pulse code modulation
Distributed control switching system

leadership in the telecommunication field, and placed ITT in a strong position in terms of its ability to satisfy demand for new products and services. At least three have had a profound significance:

- 1936. ITT scientist invents pulse code modulation[1].
- 1966. ITT scientists predict communication over glass fiber[2].
- 1978. ITT scientists patent a distributed control switching system, the forerunner of System 12[3].

Today, ITT considers that maintaining proprietary positions in certain key technologies is essential to continuing leadership in the marketplace[4]. Research and development programmes are focused on these key areas to ensure that the Corporation will continue to have enabling technologies in place when they are needed, without the need to depend on outside sources.

One of the most important of these tehnologies is VLSI circuits. ITT is active in four areas: MOS, bipolar, high voltage bipolar, and gallium arsenide. Deutsche ITT Industries' digital television chassis is an outstanding example of a leading edge application of MOS and bipolar VLSI technology – the first significant invasion of digital technology into the consumer products field.

A related technology is CAD (computer aided design). New CAD processes are required to handle the increased complexity of VLSI devices, which already exceed 100000 gates per chip. The ITT Advanced Technology Center in Shelton, Connecticut, coordinates ITT's worldwide efforts in computer aided design, engineering, and manufacture. One current project seeks to integrate the design process from requirements specification to circuit layout by codifying the knowledge of expert designers into a single system. This system accepts project specifications and block diagrams as input data, then applies engineering rules to select the best solution from among various possible implementations; it provides much more accurate results than intuitive and trial-and-error evaluation techniques[5].

Fiber optics is a basic technology that was pioneered by ITT. The Corporation now has fiber optics operations at 17 sites in Europe and North America[6], notably the Electro-Optical Products Division in Virginia, Standard Elektrik Lorenz (SEL) in Germany, and Standard Telecommunication Laboratories (STL) in England. Activities range from improving manufacturing processes for fiber and cable to the development of new detectors and integrated optical systems that can exploit the capabilities of fiber optics for broadband transmission and high signal throughput rates. SEL is a major participant in the BIGFON (broadband integrated glass fiber optical network) project in West Germany, which will result in the world's most advanced communication system offering a wide range of integrated services.

The key technologies are critical to achieving the goals of the ISDN (integrated services digital network). ITT has been a prime mover in the development of ISDN[7] capabilities through its technological achievements in telecommunication, notably System 12; participation in international standardization organizations such as the CCITT; planning of digital telecommunication networks; and field trials of ISDN implementations in Italy, Belgium, and Germany. Other efforts include experiments in digital loop transmission and distributed packet networking; development of interfaces for CCITT Recommendation X.25 protocols and local area networks; advanced system architectures; and videotext applications. The thrust is to provide value added services employing speech recognition, voice-to-text conversion, and database access, among others.

The technologies required for ISDN are also applicable to the office environment, both for the provision of integrated communication services and for office automation. Adaptation of the ITT 1240 architecture (described later) will offer a communication hub not only for linking a variety of office equipment but also for connecting multiple locations. The network itself will offer certain solutions to the office communication problem, such as electronic mail. Projects that address the provision of business and office systems include advanced terminal development at ITT Courier; PABX systems developed by ITT Telecom, ITT Austria, SEL, and other ITT telecommunication companies; optical disk technology for expanded databases at STL; local area networks and integrated voice/data PBXs at B&CC; and research in artificial intelligence at the ATC.

Future telephone and office automation systems will require greater information handling capabilities and improved man-machine interfaces. The answers lie in applying systems technology to integrate microelectronics, computer science, and programming to achieve speech, image, and knowledge processing. Projects underway at ITT laboratories include research and development into:

- advanced algorithms for speech and speaker recognition (ITT Defense Communications Division)
- image processing (ITT Gilfillan)
- knowledge bases (ATC, STL)
- advanced computer architectures to achieve the high processing throughputs that will be required (BTM, STL, ATC)
- human factors and industrial design (ITTE ESC, PTC).

As the world's second largest producer of telephones, ITT is continually improving the capabilities and features of home and office subsets and developing advanced models for ISDN applications.

Standard Electric Kirk, an ITT company in Denmark, has introduced the first digital subset, opening the way to the fully digital telephone network. Digitization of the subscriber subset is a prerequisite for the implementation of ISDN features.

A technology common to all ITT's advanced systems is programming, including programs embedded in microprocessors as well as applications programs and those supplied as part of a product (such as the System 12 test programs). ITT's programming requirements will soon reach several million source statements annually. To meet these requirements, the Corporation has mounted a worldwide programming technology effort to develop new methods and tools for improving programmer productivity; measurement and quality control techniques to assess and refine programmer output; and education programs to improve programmer skills[8]. ITT programming centers in Stratford, Connecticut, and Harlow, England, are providing the leadership for the Corporation to advance the state of the art in each of these areas.

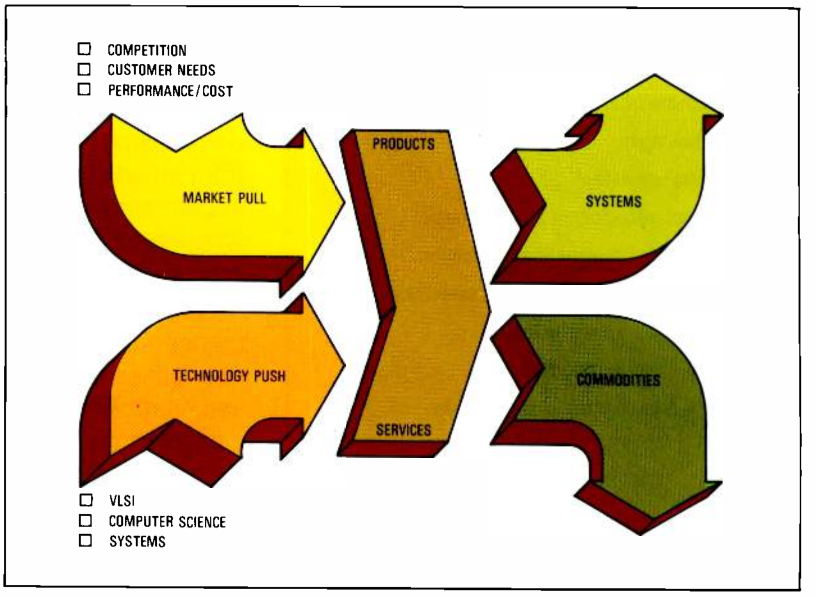


Figure 2
The new environment for technological development.

Forces Driving Technological Development

As the telephone celebrated its one-hundredth anniversary, the nature of the telecommunication industry had begun to change in some very fundamental ways. The primary reason for this change was the rapid advance in the key technologies mentioned above, particularly VLSI and programming. Whereas previously the evolution of telecommunication had been paced by the availability of technical invention, now virtually any function can be implemented through programming, and VLSI makes the implementation ever more affordable.

Technological advances have also caused a blurring between telecommunication, data processing, and office systems. Users of these systems, realizing the importance of new ISDN products and services, demand more relevant functions from the manufacturers. Piecemeal solutions to business problems are giving way to system solutions, that is, a more integrated approach to increasing revenue and reducing costs. Thus, the 100-year old technology push has a new partner, market pull (Figure 2).

Within ITT, market considerations have influenced the direction of research and development investment by providing measures of the effectiveness of new technology developments, that is, their likely ultimate impact. This coupling of assessment of administration and subscriber needs with technology development is critical primarily because of the lead times required to deploy new technology from laboratory concept to product, a period typically spanning 7 to 10 years for major new developments.

Figure 3 shows some of the elements in a systems approach to technology. The particular investments, make or buy decisions, and internal technology development programmes must be heavily influenced by marketing insight in order to maximize the value added, and thus the competitive advantage.

An example of the operation of these driving forces in the development of a technology is the smectic liquid crystal (low cost flat panel) display developed at ITT's affiliate, Standard Telecommunication Laboratories[9]. This "latching LCD" has inherent memory and is capable of large, high resolution, flat displays at low cost. The milestones for this "scheduled" invention were planned with its principal applications in mind. At the appropriate point in its development, the technology was coupled with other ITT proprietary technologies, resulting in a product that promises to have a major impact on the industry (Figure 4).

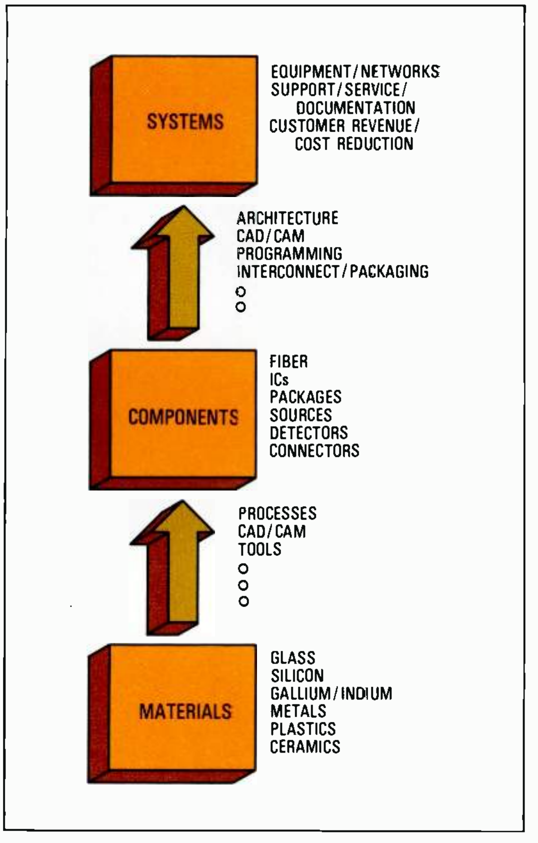


Figure 3
Vertical integration in technology.

One of the technologies critical to the success of the smectic liquid crystal display is tape automated bonding, which was developed on speculation, but in anticipation of this kind of application. This interconnect technology permits high pin counts and direct bonding to glass – both essential to making the smectic display a practical proposition.

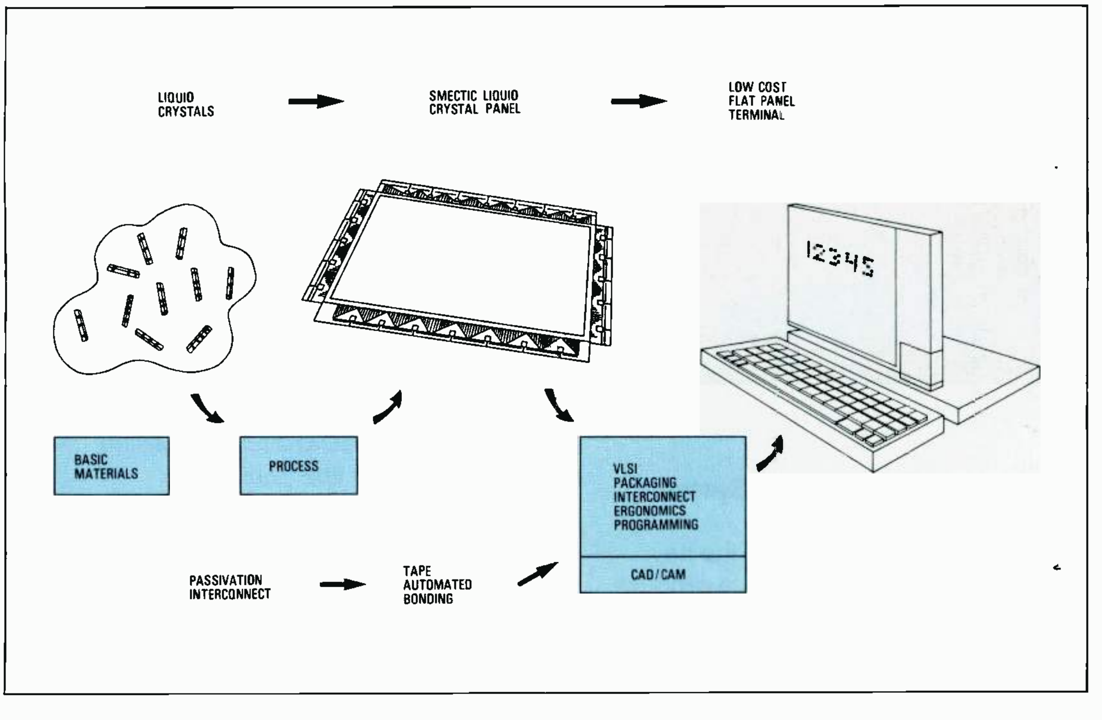


Figure 4
Elimination of the last vacuum tube.

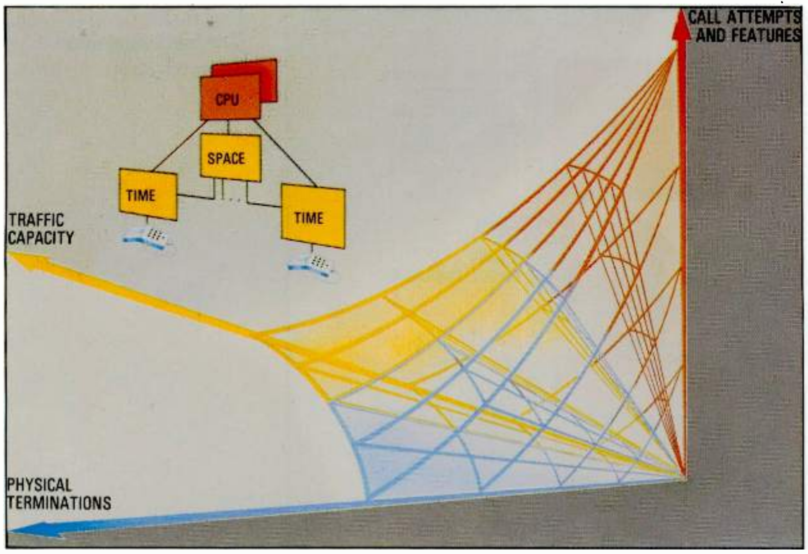
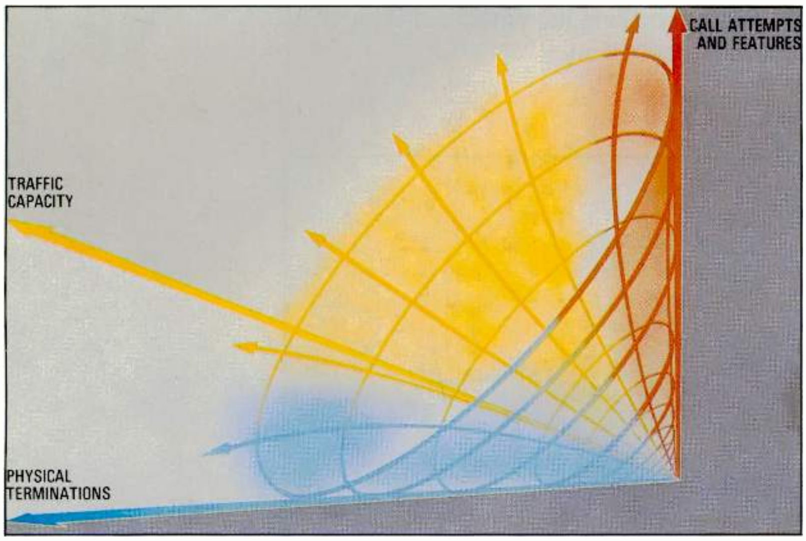


Figure 5
Traditional switching system architectures with central control place economic contraints on expansion, resulting in performance tradeoffs between features, traffic capacity, and number of ports.

Figure 6
Desired performance characteristic of a switching system allow economic growth in all dimensions without limit, with any combination of features, traffic capacity, and number of ports.



System 12: ITT's Flagship System

The most notable example of the new technology/market approach to product development is System 12[10], ITT's basic product for the integrated voice and data applications of the future. The conception of this system, in 1975, gambled on the accuracy of ITT's predictions of both technology developments, such as microprocessors and VLSI, and marketplace needs, such as data and feature requirements.

Traditional switching systems are characterized by the performance tradeoffs illustrated in Figure 5. The three interrelated parameters in the traditional approach are:

- features offered (including call attempts), which depend on the computing power of the system
- traffic carrying capacity, which is determined largely by the amount of switching hardware
- number of physical terminations (ports), which is determined by the number of subscribers served.

The most limiting of these parameters in past systems was the ability to install enough computing power, economically, to meet expanding demands. The traffic parameter was a limiting factor primarily because the actual switching matrix hardware with its control interfaces has been a high cost item.

The desired characteristic curves equivalent to those in Figure 5 are shown in Figure 6: essentially unlimited growth (or shrinkage) of equipment in place along any or all of the axes obviates the need to overengineer the inital installation according to uncertain demographics, with the attendant higher capital and other resource expenditures.

The manner in which the characteristics illustrated in Figure 6 have been achieved in the ITT 1240 Digital Exchange is shown in Figure 7. Three key innovations made this development possible:

- Proprietary patented VLSI circuits to perform both voice and data switching. The "switch port" device performs both time and space switching, has its own path memory, and contains enough intelligence to perform its own path searching. It is arranged to permit unlimited growth of the switch matrix without affecting already installed elements or line traffic.
- Patented distributed control structure in which call handling is done through cooperating intelligent terminals without the need for central control. This structure permits virtually unlimited growth along the feature (vertical) axis and overcomes

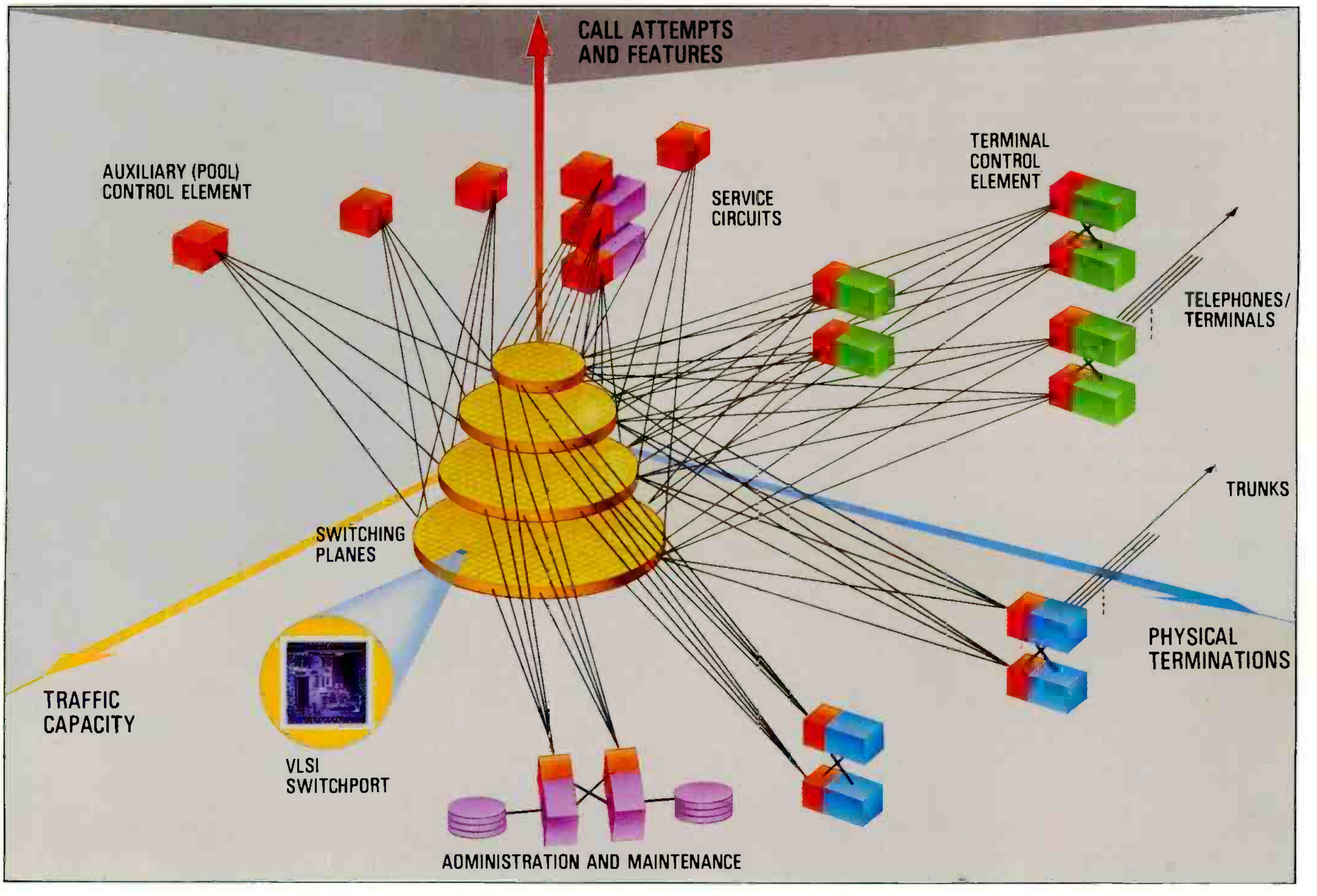


Figure 7
The ITT 1240 architecture represented by this diagram permits unlimited growth of the switching matrix through communication among distributed control elements. Switch planes can be added for greater traffic.

a major problem encountered in conventional systems. Pool processors can be added to handle unanticipated feature growth for as many terminals as desired. CHILL-based software modules run transparently on any control element.

– Proprietary, fully digital line circuit technology, in which the major transmission and signaling parameters are software settable. For example, this permits the same line interface to shift from normal telephone service to conditioned private line service without rewiring, restrapping, etc. In combination with the VLSI switch, which permits unlimited semipermanent connections, considerable capital investment can be avoided by the telephone administration.

The proof of the viability of a concept is in its implementation. The elegant simplicity of ITT 1240 is demonstrated by the small amount and low diversity of hardware. A typicall installation embodies 30 to 35 printed board types, typically one-fifth to one-tenth of the number required in conventional structures. This elegance also permits a wide range of application, both in traditional networks (rural, metropolitan, toll, gateway), and in ISDN and business applications.

Conclusions: Evolution of the Network

Advances in the key technology areas described in this article will make possible the graceful evolution of the last 100 years of telephony to the information age, while adhering to administrations' imperatives of revenue enhancement and sound capital budgeting. The building-block structure of both hardware and software elements permits maximum leverage of existing plant while making the transition to the information-based systems of the future, and minimizing the need for separate, costly overlay networks. ITT is well prepared with the technology, experience, history of innovation, and insight, and is committed to work side-by-side with telecommunication administrations throughout the world to help bring about this new era of human progress.

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Ivan A. Cermak holds BS, MS, and PhD degrees in electrical engineering from McGill University, Montreal, Canada. He has had 19 years experience in the telecommunication and computer industries, working in such areas as digital communication, computer aided design, programming, and microprocessor design. Dr Cermak was previously with Bell Telephone Laboratories in Denver, Colorado, where he held various technical and management positions, including head of the system software and advanced technology departments. He then joined ITT as head of the ATC in November, 1981. He is at present a vice president of ITT, and director of the ITT Advanced Technology Center, Shelton, Connecticut, USA. Dr Cermak is a member of the Institute of Electrical and Electronic Engineers and is on the editorial board of IEEE Spectrum.

ITT Telecommunication Products for an Evolving Network

ITT's range of telecommunication products is the most comprehensive in the world. The Corporation's commitment to Administrations, business users, and subscribers ensures that all products utilize state-of-the-art technology and are designed to allow for rapid network evolution.

G. F. Knapp
ITT Europe Inc, Brussels, Belgium

Historical Perspective

Events like Telecom 83 provide the opportunity for the telecommunication industry, the Administrations, and their equipment suppliers, to reflect upon the past, consider the present, and speculate on the future direction for communication.

As for the past, it is estimated that the nations of the world have invested over $450 billion in a globe-encircling communication network, at present primarily employing analog technology, and dedicated largely to the transmission of voice. In 1983 it is estimated that the industry will invest about $80 billion – a 6% increase in real terms compared with 1982 and the first substantial growth since the decade began. This level of investment is even more remarkable given the flat or even negative growth of the world's economy. The present state of telecommunication, therefore, is now growth oriented and, again in real terms, leading other sectors of the economy in many nations. This growth, which appears to have no limits, is based on continued expansion of telephone facilities, plus modernization and replacement of existing facilities to improve service quality and reduce maintenance. Growth is also stimulated by the wide variety of data and other non-voice services that have become economically feasible as a result of advances in microelectronics.

As for the future of the telecommunication industry, it is proper to consider the mission and responsibility of those of us whose business is telecommunication. We have, historically, provided the means whereby people are able to overcome the barriers of space and time to direct, beseech, guide, and entertain one another.

The Era of Innovation

The once conservative telecommunication industry, characterized by slowly changing technology and a reluctance to introduce new services, has changed dramatically. Now the industry is at the forefront of the drive to develop new technologies, innovative systems, and improved system architectures. An example is found in the distributed control architecture of the ITT 1240 Digital Exchange, where implementation is in advance of the computer industry. Such systems offer new and exciting services to business and home subscribers alike. Administrations and suppliers throughout the world, together with international standards organizations like the CCITT and ISO, have teamed up enthusiastically to build a new industry that will bring about nothing less than a revolution in international and domestic communication.

The world's economic processes are fundamentally dependent upon the telecommunication business. Many countries have recognized that they can advance their economies by expanding telecommunication in terms of quantity, quality, and new services. Today the world places a high value on information, in whatever form, and demands its immediate availability. For the future, therefore, more so than in the past, mankind's economic well-being is intrinsically linked to how well the telecommunication industry performs its job.

Information production has become a service industry that requires economic delivery of its product. Initially this information industry had to provide its own communication, like computer companies supplying local area networks. However, as digital technology is introduced into national communication networks, a worldwide voice and data network is growing up – a network that is geographically pervasive in a way that neither PABXs or local area networks can be.

During the past 100 years the role of the telecommunication industry has been to provide a worldwide network primarily dedicated to transmission of the human voice. The present network has been adapted to carry other forms of information, and will apparently continue to do so for years to come. However, our concept of human and indeed machine interaction has undergone a dramatic change. We now perceive voice, printed text, computer data, and video sources simply as variants of a single stream of intelligence requiring a universal mode of transmission. For years ITT has been planning and developing systems that support the transport of all forms of information – voice and any type of data – over a single digital medium.

Operator and supplier are now engaged in the gradual transformation of the world's communicating network. Simply stated the task is to employ the available technologies to allow the most cost effective and efficient movement and delivery of a multifaceted torrent of information. That transition is accelerated by the power of new technologies, the pace and pressure of human economic and social activity, and the sophistication of the end user, whose growing awareness of the potential of the information society is creating new demands on telecommunication services. The wealth of human resources coupled with increasing user expectations in this area will determine the rate of growth and penetration of the world's expanding communication network.

ITT's Role in Telecommunication

Commitment to new technology is a prerequisite for the development of state-of-the-art products which provide new features and facilities for users and are geared to rapid technological evolution. It is no longer sufficient for a product to meet todays needs – increasingly, features must be oriented towards the integrated network of the future. System design must allow advantage to be taken of technological innovation. The ITT 1240 Digital Exchange is a prime example. The modular architecture is based on a unique digital switch and distributed microprocessor-controlled terminals which require the use of the latest LSI technology and programming techniques. It is significant that ITT started design of the ITT 1240 several years before the necessary technology was available, showing faith in the ability of its international research centers to develop advanced technologies at the time they are needed, and illustrating a commitment to the most advanced engineering to meet customers' needs.

ITT is firmly committed to offering a comprehensive range of telecommunication-oriented products both to Administrations (or other operating entities) and end users. Indeed, with development houses and research centers throughout the world, the ITT Corporation is able to provide the most comprehensive range of such products available from a single source. ITT is equally able to supply a telephone subset, office communication equipment, an international exchange – or a complete digital network including installation, training, and maintenance. This product diversity has many advantages as experience in one field is frequently directly applicable to other fields. Often common technologies are employed. In addition, it ensures that each product development or exchange design is undertaken in an arena

The ITT 1240 Digital Exchange is at the heart of ITT's plans to provide a full range of equipment for voice and non-voice services in an evolving integrated services digital network.

where there is wide experience of the networks within which the exchange will operate, the terminals that will be required, and the features demanded by users. Thus exchanges, PABXs, terminals, modems, transmission facilities, and operations and maintenance centers will be fully compatible and offer complementary features and facilities. The ITT exhibit at Telecom 83 is evidence of the coordinated telecommunication product planning, development, and manufacture undertaken by ITT units in many countries.

Product Range

As already indicated, the range of telecommunication products available from ITT is so diverse that a user can meet virtually all his needs from a single source. Products on view at ITT's stand in Geneva are conveniently divided into a number of different areas, as briefly described below. However, it should be stressed that these areas, fully coordinated in an overall systems concept, are complementary.

ITT 1240 Digital Exchange

Little further need be said here about System 12, ITT's most ambitious development project ever, as it is covered elsewhere in this issue and has been dealt with in detail in *Electrical Communication*[1]. Suffice it to say that progress has led to the development of multiservice (voice and data) digital modules for ISDN field trails in Belgium and Italy, and later in Germany and Spain. As ISDN data features are added to the existing ITT 1240 by the inclusion of ISDN modules, these trials are showing the soundness of the inherently simple architectural concept and the innovative digital switching network with its almost unlimited expansion capability. In other areas, technological advances are being incorporated, supporting the 'future safe' claims. At Telecom 83, the ITT 1240 forms the core of the stand, integrating the voice and data services as it does in national networks.

Office Communication

Office communication is playing an ever larger part in the lives of most of those employed in business, from secretaries to company chairmen, as the fields of office work and telecommunication merge. The information society about which we hear so much is creating new demands on telecommunication services, with particular emphasis on the need to send a variety of types of data. With its strong telecommunication base, ITT is well placed to offer a comprehensive range of office communication equipment, including microprocessor-based intelligent terminals, communication controllers, advanced teleprinters, and facsimile machines. The new generation of digital PABXs, such as the ITT 5000 range, also falls into this category; they are already having an impact on the office environment and spearheading the evolution to an integrated services digital network.

Telecommunications Service Systems

Nowhere is ITT's commitment to the users of its equipment better illustrated than in the field of telecommunications service systems (or TSS). While technological evolution clearly benefits new products, at first sight it would appear to have a devastating effect on the anticipated service life of many existing exchanges. There is a huge potential cost to Administrations for writing off exchanges early in their lives because they can no longer provide the features demanded by users, or because they become too expensive to maintain (in comparison with the new digital exchanges). To overcome this problem, ITT has used advanced technology itself to provide a range of TSS products that enable Administrations to update subscriber, and operations and maintenance facilities to match those of the newest exchanges. It is now possible to operate and maintain a network with a diverse range of electromechanical and analog and digital stored program control exchanges from a single center.

Office communication is the area in which most people will first experience the fruits of the information revolution. ITT offers a very wide range of products to cater for almost all office communication needs.

ITT offers a comprehensive range of TSS products both for the upgrading of electromechanical and early stored program controlled exchanges, and to provide additional features in modern exchanges.

Examples of products in this category are a subscriber billing system, a remote line tester, a universal call simulator, a local call simulator, a centralized translation system for PENTACONTA* exchanges, and a network quality tester.

Transmission and Rural Systems

Whatever the transmission medium – wire pair, coaxial cable, microwave, or optical fiber – there is a strong trend towards digitization, largely as a result of the introduction of digital switching technology. Historically, ITT engineers have made important contributions to this field, including the invention of pulse code modulation and the development of optical fiber communication systems. Today ITT remains a leading supplier of transmission equipment.

* A trademark of ITT System

Analog and digital transmission systems available from ITT companies cover the complete spectrum from wire pairs, through coaxial cable and microwave systems, to the latest multimode and single mode optical fiber equipment which is capable of carrying vast amounts of information.

The availability of analog and digital transmission systems from a single supplier allows an Administration to choose the optimum system for each part of his network without worrying about problems of compatibility. Dealing with a single source also has advantages in terms of maintenance and the supply of parts.

New generation transmission products available from ITT affiliates include digital microwave and coaxial systems and an advanced 140 Mbit s^{-1} monomode optical fiber system.

However, high bit rates and wide bandwidths are not always the most important parameters. In rural areas, for example, low population densities and widely spaced communities make lower capacity systems more economic to install and operate. A 10-channel PCM system, the ITT 1240 remote subscriber unit, and a multiple access radio system are all available for such applications. In each case they have been designed by ITT units familiar with the special problems of telecommunication in rural areas.

Subsets and Small Terminals

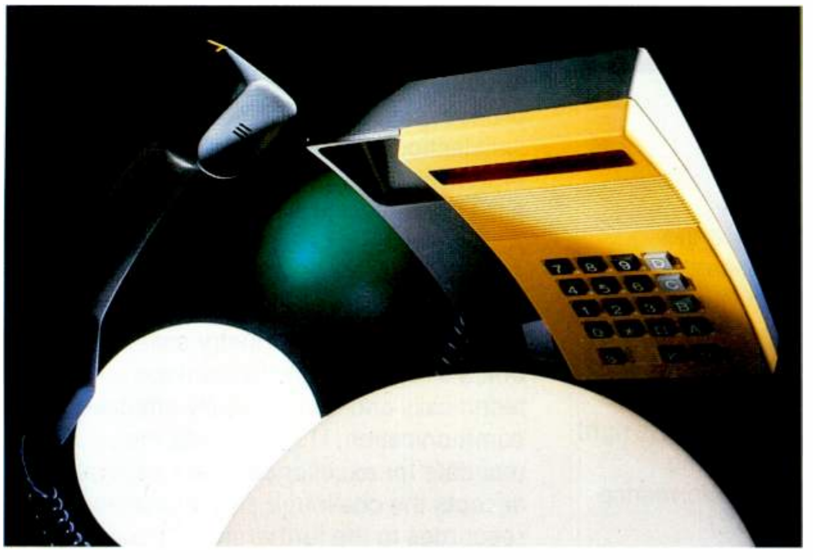
The true multinational nature of ITT is clearly visible in the wide range of subsets available from ITT units. National taste is paramount in designing a phone for domestic and office installation, so each unit offers subsets suited to the home country and its main export markets. At the same time there is move towards using common technology in outwardly different subsets.

Today, subset technology is characterized by increased subscriber demand for new features. Thus subsets now offer facilities such as abbreviated dialing, call answering/recording, automatic redial, and so on; the list is long and varied. (Of course many of these features are also provided by PABXs.) With the coming of an integrated digital network, digitization of subsets and the provision of non-voice services are increasingly important considerations, although so far digital subsets are generally limited to use with digital PABXs.

ITT also offers 'subsets' that cater for minority users such as those with a handicap. Examples are the Textphone which is designed for persons with hearing or speech handicaps, and the Vital subset which has special dial buttons and a range of facilities to assist those with visual, hearing, and physical disabilities.

Integrated Services Digital Network
As the widely heralded integrated services digital network moves from being essentially a concept to a realized product, ITT's philosophy throughout its product range is to prepare the way for full service integration based on a digital network. The ITT 1240 Digital Exchange is at the heart of this approach with its ability to cater for both voice and non-voice services.

However, while ISDN is for the medium- to long-term future, there is also a need for specialized data networks such as the DPS 25 packet switching network. Such specialized networks will be accessed through ISDN exchanges, extending their useful lifetimes as integrated services networks are established.



Each ITT company produces subsets designed to meet local and export needs for features and design. The result is an enormous range of technically advanced subsets suitable for home and office use.

The basic premise of the ITT 1240 – to permit the transition from analog to digital *and* ISDN, rather than to digital *and then* ISDN, has been realized. The equipment for this single transition is supported by a library of computer programs for digital network and ISDN planning; these are available to Administrations for their network planning and implementation exercises.

Programming Technology
Microprocessor control is at the heart of ITT's new generation products. Thus programming is now of major importance. In line with this, ITT units worldwide employ over 8000 programming staff. The corporation has built a Programming Technology Center in the USA dedicated to advancing the state of the art, and ensuring that the latest technologies and programming tools are available to programmers throughout ITT. In an area that is changing as fast as programming, ITT is committed to continual education of its staff and managers.

Product Philosophy

The products offered by ITT are the result of an intricate interaction of the Corporation's perception of administration and subscriber needs, supplier capability, and competitive reaction, together with participation in advancing the technologies required for modern communication. Of course, the primary consideration is the user, whether a large telecommunication Administration contemplating its first digital exchange and optical fiber link, or an individual end user selecting a telephone subset. The scope and complexity of the composite needs of Administration and subscriber drives ITT to employ every technology, every inventive idea, every human and business skill towards meeting their requirements.

Whatever the product, certain design guidelines are universally applied within ITT. All new ITT products make full use of state-of-the-art technology to ensure that they are reliable and easy to maintain. Indeed, most incorporate built-in test facilities. LSI and VLSI technologies are used increasingly throughout the product range, bringing with them advantages of small size, low heat dissipation, low power consumption, and automated manufacture. At the same time, careful circuit design frequently makes it possibles to eliminate, or at least minimize, the need for circuit adjustments.

It goes without saying that the performance of all ITT products meets, or exceeds, the requirements set by relevant national and international standards and regulations.

As sophisticated technical equipment finds its way into many different parts of business it is important that new products can be operated by 'naive' users, that is, those with no technical training. ITT is committed to making equipment 'user friendly', and employs human factors engineers from the outset of any design. Here, programming technology can, perhaps, make the most important contribution. As memory becomes cheaper almost day by day, it will be possible to write programs that make it feasible for users to operate the equipment with little training beyond that needed for their job functions.

Programming is the key to unlocking the power of modern microprocessor technology for the benefit of users. This means increased emphasis on making microcomputer programs easy to use.

Relations with Suppliers

No single business concern has the capability nor the economic incentive to produce every component in its products. ITT's selection of suppliers is in keeping with the Corporation's own high standards of component and product quality. The ability to deliver the right product, at the right time, is a cooperative effort with the responsibility for quality and performance squarely on the shoulders of ITT.

Technology is introduced into the local industries of each country where ITT has laboratories, research centers, or development groups, using training and administration staff. In addition, technology is transferred wherever local manufacturing under licence is established. In this respect ITT endeavors to meet the individual needs of each country and Administration by being an important source of technology and experience.

Today's Market

The telecommunication market, despite its growth, is more competitive than ever, and ITT's ability to respond relies heavily upon the strengths of its research centers and the skills of staff and management throughout the world, together with its substantial experience of the technical, operational, and financial needs of Administrations. Indeed, the competitive strengths of ITT reflect this: diversity and excellence of technological development, breadth of worldwide operational experience, and its financial performance. ITT's objective is to *set the standard* for innovation, quality, and functionality.

Conclusions

The message here is quite simple: ITT's product philosophy is dedicated to the satisfaction of customer needs by employing the world's leading technologies. It is ITT's policy to participate with Administrations worldwide in transforming the future of telecommunication.

Referring to the earlier idea that the telecommunication industry collectively bears a responsibility to mankind to provide technically and economically effective communication, ITT interprets this as a mandate for excellence. The Corporation accepts the challenge and dedicates its resources to the furtherance of economic health and world peace.

Reference

1 Special issue on the ITT 1240 Digital Exchange: *Electrical Communication,* 1981, volume 56, no 2/3.

George F. Knapp was born in 1932. He holds a BEE degree in electrical engineering from Manhattan college and a master's degree in business administration from New York University. He is also a graduate of Harvard University's advanced management programme.
Mr Knapp joined ITT in 1966, becoming president of the Puerto Rico Telephone Company in 1970. He was elected a vice president of ITT in 1976. After holding the positions of chairman and chief executive officer of UST&T and chairman of ITT World Communications, in 1982 Mr Knapp moved to ITT Europe as director of market and product management for telecommunications and electronics.

Designing and Planning a Telecommunication Stand

Careful setting of the objectives, planning, and the judicious use of technology are essential to any successful product development. This was equally true of the design and construction of ITT's corporate stand for Telecom 83.

E. J. Gerrity
ITT Headquarters, New York, USA

Introduction

Telecom exhibitions, held every four years under the auspices of the International Telecommunications Union, are among the world's major shows of telecommunication equipment. Telecom 83, which is being held in the new Palexpo exhibition center near Geneva airport from 26 October to 1 November 1983, is no exception with some 200 000 visitors predicted this year.

Because of the significance of Telecom 83, ITT Corporation – one of the world's largest suppliers of telecommunication systems and equipment – expended considerable effort in designing and planning its corporate stand. In addition, several ITT units will be represented in their national pavilions. The ITT corporate stand will display a wide variety of products from ITT affiliated companies throughout the world, showing the unparalleled diversity of equipment available from a single supplier.

The equipment itself is covered in detail in this issue, but what is frequently not appreciated is that the design, planning, and construction of such a stand is itself a major accomplishment which takes years to complete and makes use of many of the skills available in ITT. In fact, work on planning the stand for Telecom 83 started soon after Telecom 79 concluded, and has now come to fruition four years later.

Early sketch by the stand designer illustrating his concept for the ITT Telecom 83 stand.

Design Objectives

As with any other major project, the first stage was to decide on the objectives that should be achieved by the stand. Predominant was the aim of showing the most comprehensive integrated range of telecommunication equipment and services available from any company in the world, with the unique ITT System 12 digital switching system as the major exhibit. It is no longer sufficient merely to present products, however well designed, on attractive backdrops for visitors to look at. Performance and facilities are of overriding importance to potential users. Thus an early decision was made that wherever feasible in an exhibition environment, equipment should be operational and thus able to demonstrate its performance. An important theme of the exhibit in view of ITT's commitment to a future ISDN (integrated services digital network) was to integrate the majority of working equipment to demonstrate the power and versatility of such a network based on the ITT 1240 Digital Exchange.

In contrast to the design of a telecommunication product, further objectives dealt with intangible concepts such as 'corporate image' and 'visitor appeal'. Thus marketing, public relations, and advertising personnel as well as technical staff were all involved in bringing this major project to fruition.

Another important aspect of ITT is its truly multinational nature, and this was to be reflected on the stand. Each national company is able to offer long experience with local conditions, combined with the advanced technology that is possible only from a multinational company. In addition, each unit contributes to the national economy by employing local labor and exporting finished products.

Visitors

No discussion of the design considerations would be complete without a look at who will visit the ITT corporate stand.

First, there will be government officials and PTT delegates from each of the 158 member countries of the ITU. They will be seeking ways of improving their national networks in the light of recent changes in technology, and looking for equipment that is suited to their local conditions. Such visitors are not only looking for advanced technology with which to expand their network and services, but in view of the size of their investment in telecommunication they are looking also for solutions to many different network problems, including that of upgrading existing equipment.

Increasingly, Administrations are looking for entire network solutions, for coordinated strategies covering switching, transmission, data, operations, and so on – the ISDN approach. They must be convinced of continuity, field support, and expansion capability in terms of new equipment and services. In addition they may require assistance with technical procedures such as network planning.

Second there will be a broad spectrum of delegates from the business world – from communication network managers responsible for large corporate networks to directors of small businesses wishing to take their first steps into the realm of office automation.

Third are the scientists and engineers who will be looking at the latest state of the art, expanding their knowledge of what is being done elsewhere, forming expert opinions on components and subsystems, and looking at practical implementations of advanced technologies that they could usefully include within their own systems.

View of a model of the ITT corporate stand showing the entrance porch.

Finally, on the last day Telecom 83 opens its doors to those on whom the industry ultimately depends – the telephone subscribers themselves – the general public. They will come from technical interest and curiosity. What they see will hopefully expand their knowledge about the information technology revolution which is ultimately for their benefit.

Other Considerations

A whole host of major and minor points have to be discussed and solutions found to the many problems that arise to ensure that the construction of the stand proceeds smoothly.

Lighting is important both to provide appropriate illumination for each product and to focus attention in the right places. In addition it must in no way interfere with the audio-visual shows that are part of the stand. Similarly, acoustics in the auditorium

Three members of the team that organized ITT's stand for Telecom 83, viewing the stand model.

and the sound systems for the audio-visual have to be carefully worked out to ensure that visitors can converse easily among themselves and with the demonstrators.

Ventilation and safety procedures are also of importance in view of the very large numbers of expected visitors.

Choosing a Design

With these objectives clearly set out, the stand design contract was put out to several design companies for proposals. These were then evaluated by management on the basis of how well they met the set objectives, and a contractor was then selected.

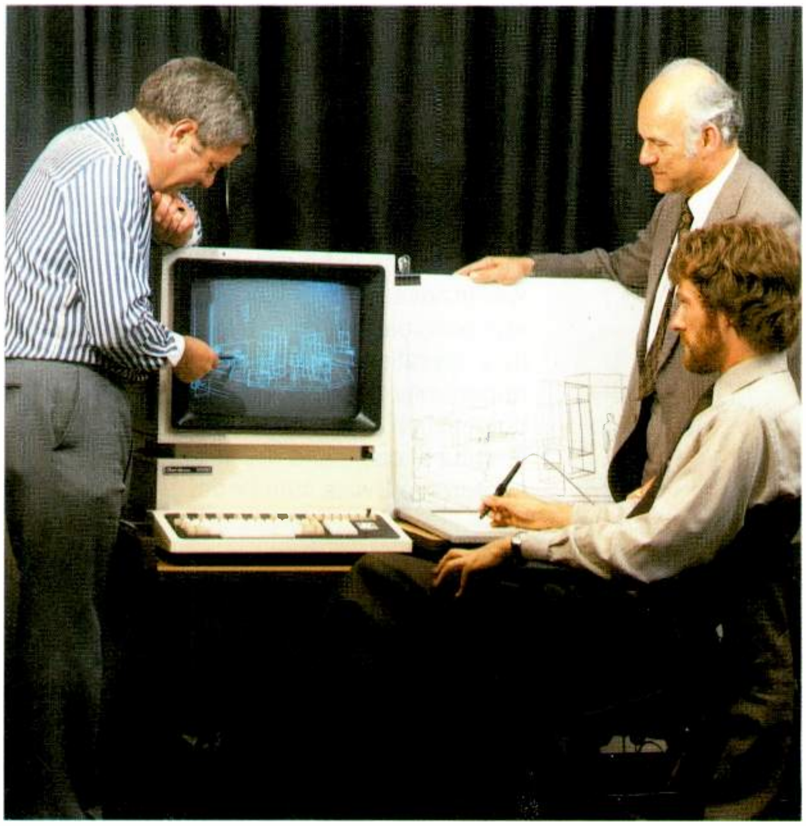
The photographs opposite show a model of the selected design by British designer Richard Bridge. The impact of the exterior design, with its cladding of aluminum, is immediate. At the main entry point to the stand is a large Technamation display which summarizes the theme of the stand – the integrated services digital network. Other radial aisles draw the eye to the center of this essentially octagonal design, to the ITT System 12 which has itself been designed to allow for service integration.

Surrounding the ITT 1240 are a number of stand segments devoted to different product areas – office communication, ISDN, transmission and rural equipment, telecommunications service systems, programming, and subsets. Much of the equipment on display is integrated and working with the ITT 1240 on the stand, and through the ITT 1240 with equipment on the stands of individual ITT companies, thus demonstrating the reality of the integrated services digital network concept.

The largest of the stand segments is devoted to the rapidly expanding field of office communication and automation. New generation digital PABXs, fast facsimile, teleprinters, teletext, subscriber subsets, and powerful microcomputers are all working with one another showing a wide range of possibilities for the 'office of the future'.

Telecommunications service systems are primarily of interest to Administration visitors, offering equipment for upgrading existing exchanges by providing new features for older exchanges, and enabling testing and maintenance to be centralized. Similarly, transmission and rural equipment are primarily the province of the Administrations, with products ranging from digital optical fiber, microwave, and coaxial transmission systems to the ITT 1240 remote subscriber unit and multiple access radio equipment for rural applications.

Programming is increasingly important throughout the product range, so one segment of the stand is devoted to showing visitors ITT's advanced concepts in this area. Six ITT personal computers offer the chance to learn interactively about the work underway at ITT's Programming Technology Center in the USA.



Computer-aided design was used to finalize equipment layouts.

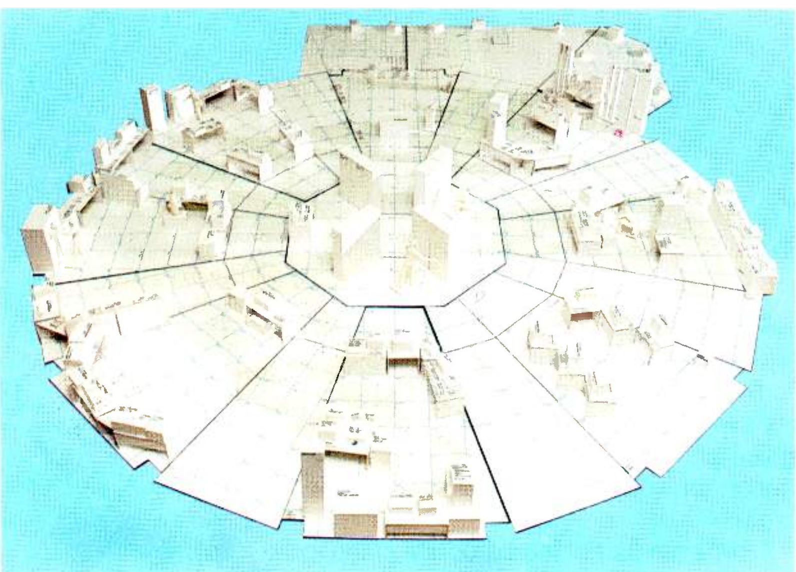
Finally, subsets are of interest to all – Administrations, business users, and home users. Also included in this area are key systems for smaller businesses and miscellaneous small terminals, including a 'telephone' for the deaf and a pocket radio pager.

A separate part of the corporate stand is devoted to ITT Communications and Information Services Inc. This unit was formed to unify ITT's service capabilities in the fields of communication, software development, and information management. This area of the stand offers major demonstrations of a news and information center; an electronic message exchange; electronic yellow pages and directory operation services; and three data communication functions (database access, compatibility conversion, and facsimile).

Planning

Selecting a design was but the beginning of the massive planning operation needed to bring the design to fruition at the right time in the exhibition hall in Geneva. The actual construction of the stand was subcontracted and ITT undertook the major tasks of selecting equipment for the displays to ensure a truly representative selection of equipment from ITT units – both large and small – and the integration of this equipment into a working integrated services digital network.

The planning and setting up of this small scale ISDN was in itself a major accomplishment. It is virtually a national network in miniature and demonstrates that ITT has indeed mastered and implemented the technology and practice of ISDN. The complete communication network and terminals had to be assembled and tested well in advance of Telecom 83. In this way it was possible to ensure that the network was fully operational. It also provided an opportunity to sort out seemingly minor points such as the provision of the correct lengths of cable and mains plugs that conform to Swiss standards.



Card model of the stand and equipment which was used prior to transferring the data to the computer for CAD.

After the complete integrated equipment had proved itself in these trials, it was shipped to Geneva to arrive three weeks before the start of Telecom 83. The final stage then started in earnest. With only 21 days in which to build the stand, put all the equipment into place, and bring it into full operation, speed was essential and at this stage the careful planning fully justified itself. There were no major last minute problems and the stand was ready well in time for the opening of Telecom 83 on 26 October.

Design Aids

Once the overall design concept for the stand had been chosen, there was still considerable work left in arranging practical equipment layouts within each of the segments. It was important that these layouts should allow the free flow of a large number of visitors, permitting the visitor who wishes to see a particular piece of equipment or a specific demonstration to locate it rapidly, while at the same time allowing others to study a wide range of equipment in detail, or simply to browse. Demonstration areas had to allow space for people to gather, and there had to be free space to allow people to chat or watch the visual displays.

An early layout was designed using the traditional cardboard model. However, computer aided design techniques were then used to refine the layout. This allowed the various stand segments to be displayed individually and equipment moved around within these areas, bearing in mind the above requirements. As the CAD software made it possible to generate perspective views from any angle, it helped to check that there were free passageways, and that no equipment interrupted lines of sight to the projector screens. It was particularly useful for such details as determining where power sockets should be located and for checking the cable runs.

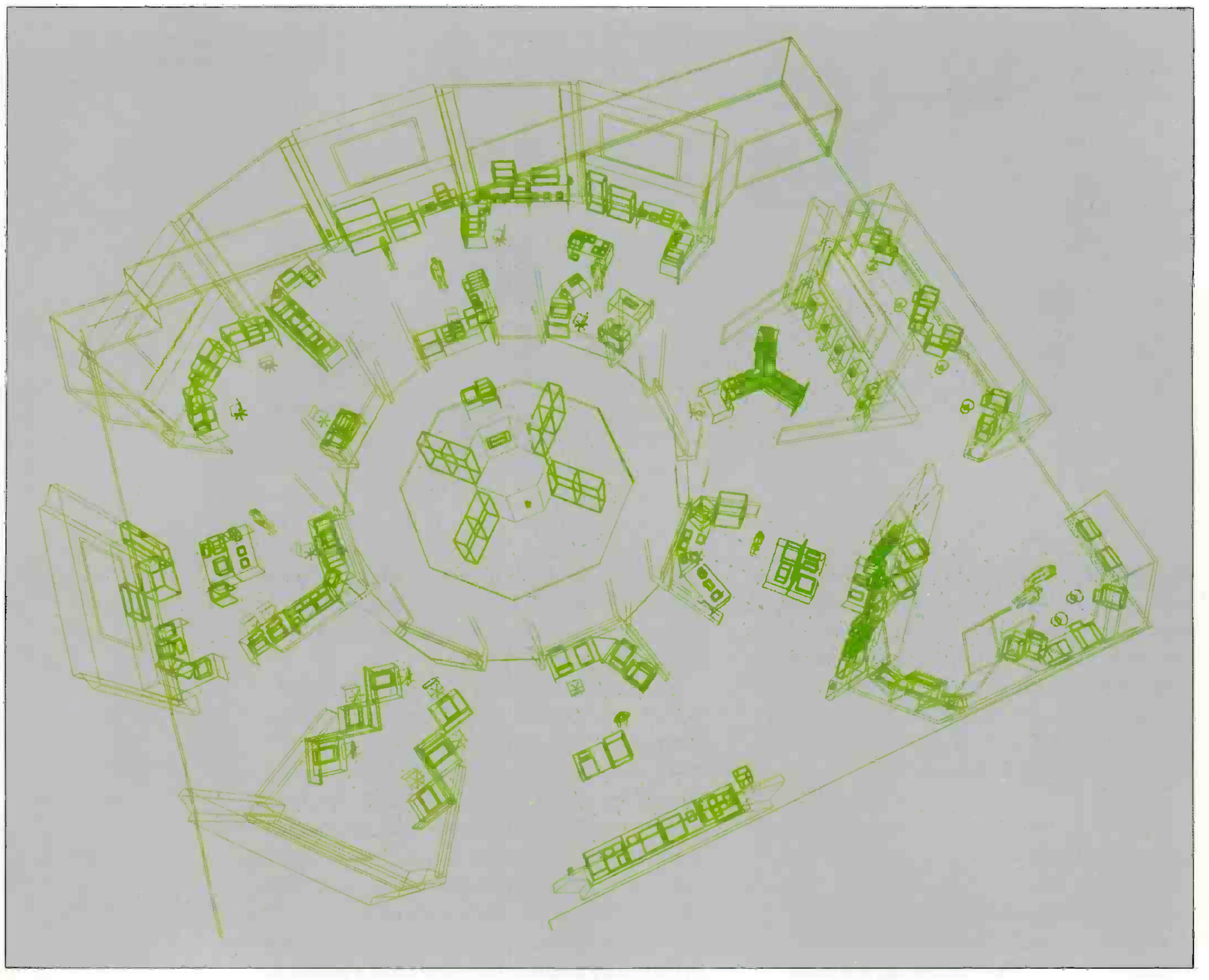
Audio-Visual Presentation

Projection Facilities

Once inside the stand it is possible to see the eight large projection screens for the audio-visual presentation. The design is such that an uninterrupted view of the screens is possible from anywhere within the stand area. Each screen has a dedicated audio channel and three slide projectors which are mounted in the central core above the ITT 1240. A laser system is able to write either on an individual screen or on all eight screens simultaneously.

Audio-Visual Programme

The audio-visual programme is shown throughout each day. It consists of two



CAD plot of the stand. Using this technique it was possible to view the layout from any angle, and to zoom in on individual sections.

distinct parts – a silent slide show and a full audio-visual presentation of ITT's capability for integrated communication.

The slide show consists of a five minute long sequence of slides which runs continuously for 55 minutes in each hour. A different set of slides is shown on each of the eight screens, the theme for each set relating to the exhibits within that sector of the stand.

Instead of simply showing views of the products within the various sectors, the slide sequences have been designed to provide visitors with a visual impression of the purpose and functions of the products. A wide range of effects can be created by fading in and out slides using a sophisticated computer controlled projector system. To achieve these effects, three projectors are used per screen, each of which can be faded in or out over periods ranging from virtually instantaneously to 30 seconds.

Every hour, on the hour, the slide shows give way to the full audio-visual presentation which occupies the remaining five minutes. All eight screens are used to present this spectacular audio-visual which uses laser-generated graphics, a full narrative, and specially selected backing music to support the studio-produced visuals.

Audio-Visual System

The visual part of the show is made up entirely of slides being faded in and out with supporting laser and lighting effects, each of which occurs at exactly the right moment relative to the sound track. Cuing of these events is controlled by a computer using the equipment shown in Figure 1.

The exact instant at which each slide change, laser effect, or lighting adjustment should take place is determined by cues recorded on one track of the sound tape, ensuring that they occur at the right moments.

The computer sends its cuing signals to

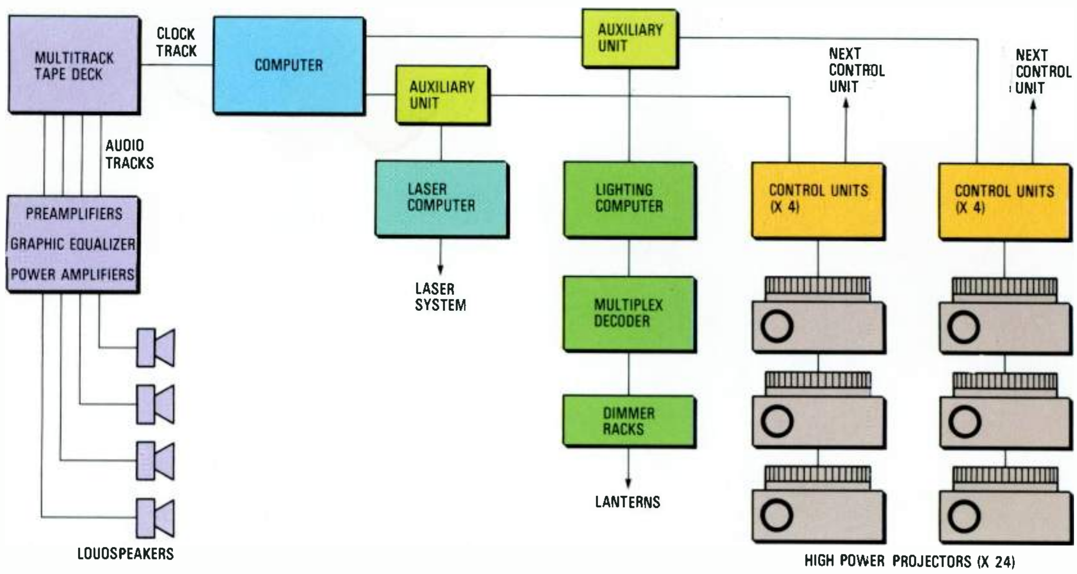


Figure 1
Schematic of the computer-controlled audio-visual system.

the projection, laser, and lighting equipment via two outputs as time division multiplexed signals (Figure 1). Each control unit decodes the lamp intensity and speed of change information for each of its three projectors from this signal. The two auxiliary units simply act as cuing devices for the laser and lighting systems.

Laser System

A block diagram of the laser system is shown in Figure 2. White light from the krypton laser is directed through a color separator which produces four separate beams of laser light – red, blue, green, and the original white. These four beams are then passed through an optical modulator which can transmit and block each of the colored beams alternately at a switching rate of 50 kHz. The color of the outgoing beam can thus be varied with time, enabling composite colors to be produced and making it possible to 'write' in different colors on different parts of the screen.

The modulated beam is passed into a fiber optic distribution switch which enables the single laser to feed all eight screens. Laser light is projected at each screen by a dedicated scanning head.

Each scanning head consists of a small mirror mounted on a platform which can be rotated about both horizontal and vertical axes using a high speed, high precision servo. An image is produced on the screen by moving the spot of laser light repeatedly along the outline of the image in the same manner as a trace is produced on the screen of an oscilloscope. As the mechanical servos cannot move fast enough to produce a picture by this method, the laser system is limited to producing hard outlines in a variety of colours.

Laser Control Unit

The color separator, modulator, fiber-optic switch, and eight scanning heads are all controlled in real time by a controller. This is in effect a specialized microcomputer system whose memory contains both the data for generating the various shapes and patterns that make up the display programme, together with the software for

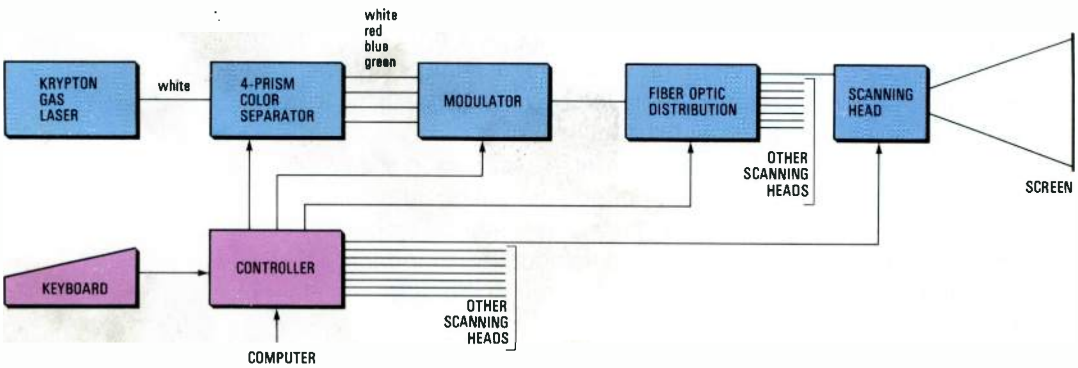


Figure 2
Schematic of the laser system which can write on any of the screens or on all eight screens simultaneously.

converting it into real-time control signals which cause the optical devices to generate the images.

As many as 20 to 30 outline images can be stored in the controller's memory for any given presentation. Information on the design of these images is fed into the controller through a graphics tablet using a light pen. Once the images have been test-projected, they are off-loaded onto tape cassette ready for reloading when the equipment is ready for the presentation.

During a presentation, the controller receives its signals from the computer that cues the slide projectors.

Lighting System

All lighting within the auditorium is controlled by a lighting computer, thus making it possible to integrate changes in the lighting in all or part of the stand with the sound and vision of the presentation. Each desired lighting effect used to support the presentation is programmed into the computer along with cuing data giving the sequence in which the effects are to be activated.

Throughout a show, the lighting computer receives cues from the main system computer via an auxiliary unit to tell it when to change to the next lighting effect in its internally stored sequence.

Conclusions

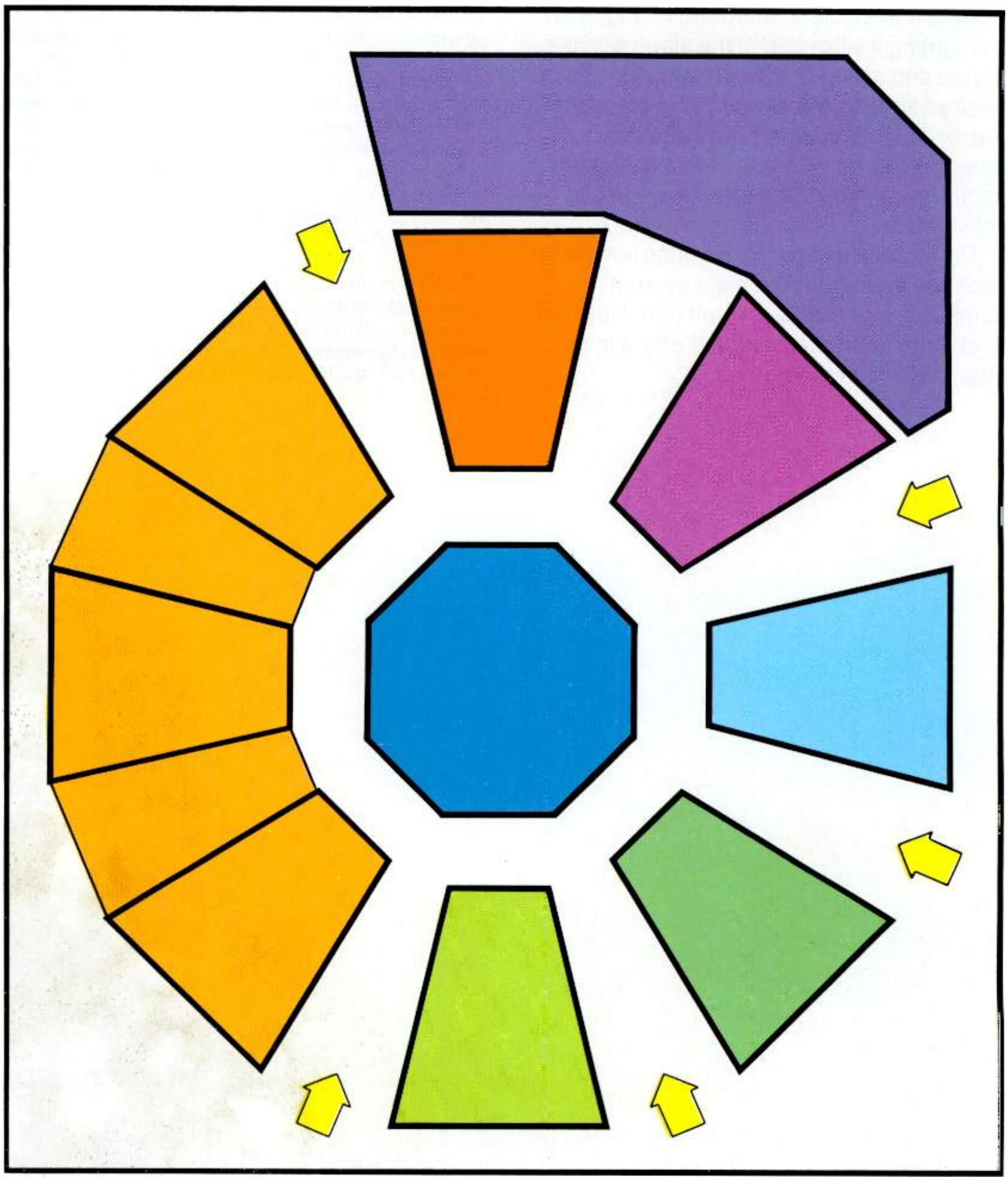
Planning and realizing the ITT corporate stand at Telecom 83 was a major task which required both design skills and considerable technical expertise to complete successfully. Perhaps the major technical problem was integration of the equipment into a small scale integrated services digital network. This experience in itself has proved invaluable to the ITT units – experience that can be passed on to equipment users. As one ITT engineer observed: "This is more than any one customer is ever likely to need, but if we get an order for something similar, I hope we get a bit more than three weeks to put it all together."

Edward J. Gerrity Jr received his BS from the University of Scranton and an MS from the Graduate School of Journalism, Columbia University. In 1965, the University of Scranton awarded him an honorary degree of Doctor of Laws. Mr Gerrity joined ITT in 1958 after serving as a columnist and a member of the editorial staff for the *Scranton Times*. He was elected a vice president and director of public relations for ITT in 1961, and later assumed additional duties as director of advertising and public relations. Three years later he was made a senior vice president and director of corporate relations and advertising for the ITT Corporation. In 1971, *PR News* named him Public Relations Professional of the Year.

In addition to his position with ITT, Mr Gerrity is a director of the International Economic Policy Association, and a director of the Bank of Commerce of New York. He is a member of many organizations including the American Management Association, the Economic Club of New York, and the National Press Club.

A Guide to the Products and Companies Represented on the ITT Corporate Stand at Telecom 83

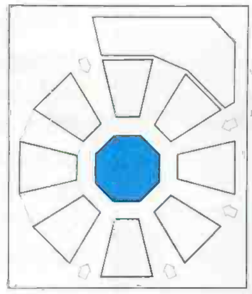
ITT's stand at Telecom 83 brings to a focus years of effort involving ITT companies in many countries. In the preparation of this special issue of *Electrical Communication* the Editors have come into close contact with all the contributing ITT companies as well as the stand designers and builders: their conclusion is that this is an event not to be missed. For those who visit Telecom 83 the journal will be a useful record. To our many subscribers throughout the world this issue gives a broad view of ITT's telecommunication products and technologies.



Stylized plan view of the ITT corporate stand at Telecom 83

ITT 1240 Digital Exchange

The fully distributed control structure of the ITT 1240 Digital Exchange gives unprecedented flexibility in exchange configuration. Local and toll applications are covered over a wide size range, with smooth growth at any stage.



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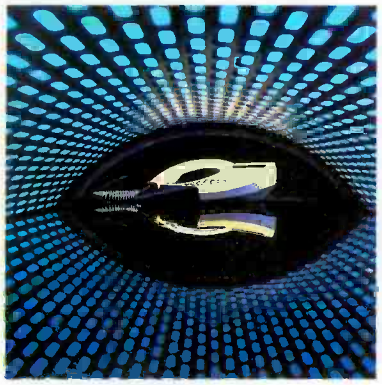
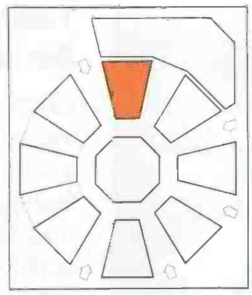


Telephone Subsets

Microelectronics has revolutionized the telephone service, and not least in the subscriber's apparatus, which offers reliability, compactness and a host of new features.



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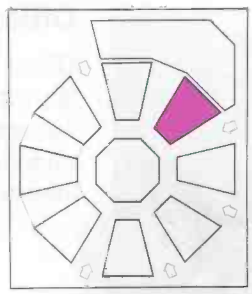
SESA
SRT
STC

Transmission and Rural

Transmission is undergoing a major revolution, the most important aspects of which relate to digitization of all parts of the network and the implementation of broadband networks to provide new subscriber services. New technology is providing cost effective solutions for expansion of the telephone network to remote subscribers in rural areas.



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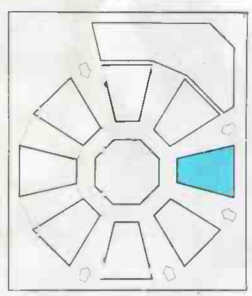
Integrated Services Digital Network

With the advent of the ITT 1240 Digital Exchange the integrated services digital network has become a reality, able to bring voice and data services to every subscriber, and interconnecting a wide range of new terminals.



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BTM
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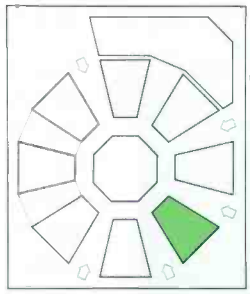
Programming

Increasingly, the whole spectrum of telecommunication products from digital exchanges to subscribers' subsets will depend on the quality of programming in order to achieve high performance and cost effective design.



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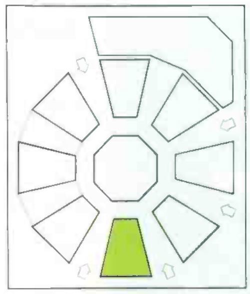
PTC

Telecommunications Service Systems

Existing exchanges, representing massive investment, can now offer a wide range of new subscriber features and improved maintenance facilities by the addition of state-of-the-art TSS products.



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NSEM
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STC
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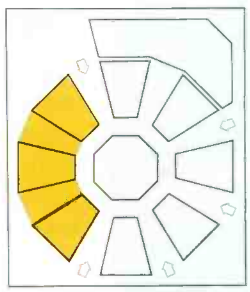
TAISEL

Office Communications

Office communications are vital in a technological world where the success of a business depends on effective handling and transfer of information.



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BTM
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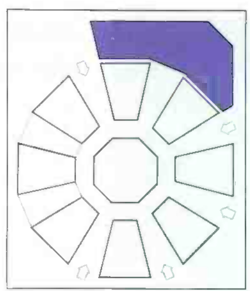
ITT Communications and Information Services

A number of companies, grouped under the banner of ITT COINS, offer comprehensive communication services ranging from a convenient news and information service to assistance with directory preparation.



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ITT
COINS

ATC

ITT Advanced Technology Center

1 Research Drive
SHELTON
Connecticut 06484
USA

FACE

FACE Finanziaria SpA

Via Monte Rosa 15
MILAN 20149
Italy

ITT COINS

ITT Communications and Information Services Inc

100 Plaza Drive
SECAUCUS
New Jersey 07096
USA

SEK

Standard Electric Kirk A/S

Ane Stauningsvej 21
DK 8700 HORSENS
Denmark

SEP

Standard Electric Puhelinteollisuus OY

Valimotie 13
00380 HELSINKI 38
Finland

SRT

Standard Radio & Telefon AB

Sorterargatan 8
S-16226 VALLINGBY 1
Sweden

STK

Standard Telefon og Kabelfabrik A/S

PO Box 60
Økern
OSLO 5
Norway

TAISEL

Taiwan International Standard Electronics Limited

4 Ming Shen Street
Tu Chen Industrial District
TU CHEN, TAIPEI HSIEN
Taiwan 236

BTM

Bell Telephone Manufacturing Company SA

1 Place Francis Welles
2000 ANTWERP
Belgium

ITTA

ITT Austria GmbH

Scheydgasse 41
A-1220 VIENNA
Austria

NSEM

Nederlandsche Standard Electric Maatschappij BV

Iste Van Der Kunstraat 292
THE HAGUE
Netherlands

SEL

Standard Elektrik Lorenz AG

Hellmuth-Hirth-Strasse 42
7000 STUTTGART 40
Federal Republic of Germany

SESA

Standard Eléctrica SA

Ramírez de Prado 5
MADRID 7
Spain

STC

Standard Telephones and Cables plc

190 Strand
LONDON WC2R 1DU
England

STR

Standard Telephon und Radio AG

Friesenbergstrasse 75
8055 ZURICH
Switzerland

PTC

ITT Programming Technology Center

1000 Oronoque Lane
STRATFORD
Connecticut 06497
USA

Integrated Services Digital Network

With the advent of the ITT 1240 Digital Exchange the integrated services digital network has become reality, able to bring voice and non-voice services to every subscriber. ITT 1240 interconnects a wide range of voice and data equipment, including telephones, fast facsimile machines, and viewdata terminals.

Introduction

The ISDN (integrated services digital network) concept can be defined as follows: it is a network that will evolve from the integrated digital telephone network and provide for end-to-end digital connectivity to support a wide range of services, including voice and non-voice services, to which users will have access via a limited set of standard multipurpose interfaces. The key characteristic of ISDN is its ability to offer the individual telephone subscriber a variety of non-voice services in addition to the telephone service.

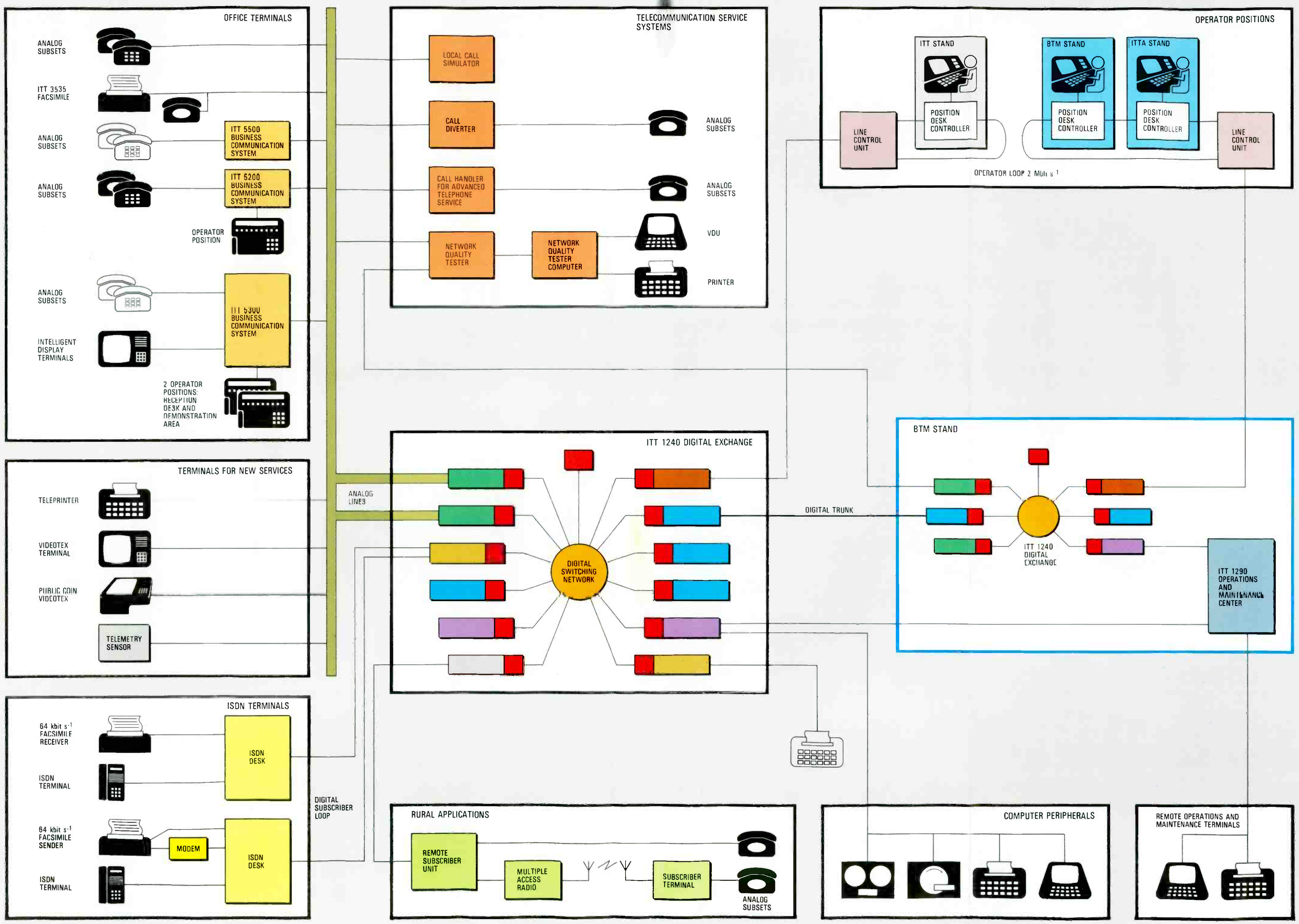
The main objective of ISDN is the combination of economy and flexibility provided by a single telecommunication network that will be able to handle as yet undefined new services.

In the past, as a new data (non-voice) service has been introduced, a separate network has generally been set up either by the PTT or a private operating company. However, with the current proliferation of such services it no longer makes sense to implement each one on a separate network and so the idea of an ISDN has been born. The natural starting point for such an integrated network is the integrated digital network already emerging for voice (telephone) communication.

Although data services are expanding more rapidly than telephone service in most developed countries, the number of subscribers to such services is still only of the order of one or two percent of the number of telephone subscribers. While this percentage is likely to increase considerably by the end of the century, telephony will remain the prime service – at least within the foreseeable future. Thus a basic requirement for the introduction of the ISDN is that the cost of implementation should not have a significant effect on the cost of the basic telephone service.

Because of the massive investment in existing, non-integrated equipment, full implementation is likely to take many years. However, the technology is already available, as the equipment on the ITT stand illustrates. The basis of ITT's display is a small-scale, but nonetheless comprehensive, integrated network capable of transmitting and switching voice and non-voice services over a digital network based on the advanced ITT 1240 Digital Exchange. In contrast to other digital exchanges, the ITT 1240 was designed from the outset to carry both voice and non-voice services, thereby speeding up the inevitable introduction of the ISDN. At the same time it meets the criterion for low additional cost for the addition of the new services. Flexibility and modularity of both hardware and program elements are the basic ingredients for an exchange that is to remain cost-effective over a long period in the light of changing hardware technology and increasing demand for non-voice services. In the gradual transition towards ISDN, an exchange architecture that allows flexible growth of switching capacity, processing power, and terminal functions will readily adapt to new requirements as they occur. These qualities are all present in the ITT 1240.

The fold-out block diagram shows how the equipment is integrated. Services available include videotex, teletex, facsimile, and telex, as well as telephony (including digital PABXs). Access is also available to the network through a multiple access radio connected to the ITT 1240 remote subscriber unit. A comprehensive set of telecommunications service systems modules is connected through the line circuits, demonstrating a range of products that enhance facilities in existing telecommunication networks. These are conveniently and economically implemented by modular units peripheral to old and new exchanges.


OFFICE TERMINALS
ANALOG SUBSETS
ITT 3535 FACSIMILE
ANALOG SUBSETS
ITT 5500 BUSINESS COMMUNICATION SYSTEM
ANALOG SUBSETS
ITT 5200 BUSINESS COMMUNICATION SYSTEM
OPERATOR POSITION
ANALOG SUBSETS
ITT 5300 BUSINESS COMMUNICATION SYSTEM
INTELLIGENT DISPLAY TERMINALS
2 OPERATOR POSITIONS: RECEPTION DESK AND DEMONSTRATION AREA
TELECOMMUNICATION SERVICE SYSTEMS
LOCAL CALL SIMULATOR
CALL DIVERTER
CALL HANDLER FOR ADVANCED TELEPHONE SERVICE
NETWORK QUALITY TESTER
NETWORK QUALITY TESTER COMPUTER
ANALOG SUBSETS
ANALOG SUBSETS
VDU
PRINTER
OPERATOR POSITIONS
ITT STAND
BTM STAND
ITTA STAND
POSITION DESK CONTROLLER
POSITION DESK CONTROLLER
POSITION DESK CONTROLLER
LINE CONTROL UNIT
LINE CONTROL UNIT
OPERATOR LOOP 2 Mbit s-1
TERMINALS FOR NEW SERVICES
TELEPRINTER
VIDEOTEX TERMINAL
PUBLIC COIN VIDEOTEX
TELEMETRY SENSOR
ANALOG LINES
ITT 1240 DIGITAL EXCHANGE
DIGITAL SWITCHING NETWORK
DIGITAL TRUNK
BTM STAND
ITT 1240 DIGITAL EXCHANGE
ITT 1290 OPERATIONS AND MAINTENANCE CENTER
ISDN TERMINALS
64 kbit s-1 FACSIMILE RECEIVER
ISDN TERMINAL
64 kbit s-1 FACSIMILE SENDER
MODEM
ISDN TERMINAL
ISDN DESK
ISDN DESK
DIGITAL SUBSCRIBER LOOP
RURAL APPLICATIONS
REMOTE SUBSCRIBER UNIT
MULTIPLE ACCESS RADIO
SUBSCRIBER TERMINAL
ANALOG SUBSETS
COMPUTER PERIPHERALS
REMOTE OPERATIONS AND MAINTENANCE TERMINALS

ISDN Voice-Data Demonstration

The capability of ITT 1240 to switch voice and data simultaneously is demonstrated using the ISDN terminal. The user selects voice service by lifting the handset: dial tone is received and 'DIAL' is displayed on the voice part of the display. The desired number is entered via the numeric keypad and displayed. If necessary the number can be amended using the clear key. The 'DIAL' key is operated to dial the call and establish the digital voice connection. An incoming voice call is signaled by a tone and 'ACCEPT CALL' on the voice display: the call is accepted by lifting the handset.

To select data service the user operates the 'FAX' key. In response 'DIAL' is displayed on the data part of the display; no dial tone is received. The desired number is entered as for the voice service and the 'DIAL' key operated to set up the data call. Discrimination between standard and fast (64 kbit s^{-1}) facsimile stations is performed automatically, as are speed selection and facsimile control. Following receipt of a facsimile response either 'FFAX PROG' (fast Fax in progress) or "SFAX PROG' (slow Fax in progress) is displayed. Upon completion of data transmission "FAX FINISH' is displayed for several seconds.

ISDN terminal.

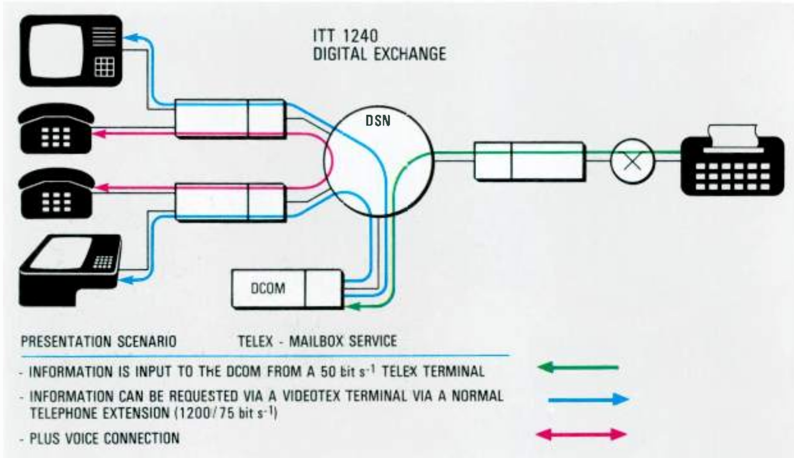


Figure 1
Telex-mailbox service using the data communication module.

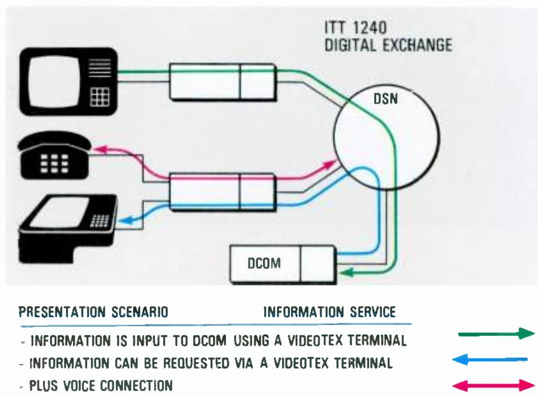


Figure 2
Information service using data communication module.

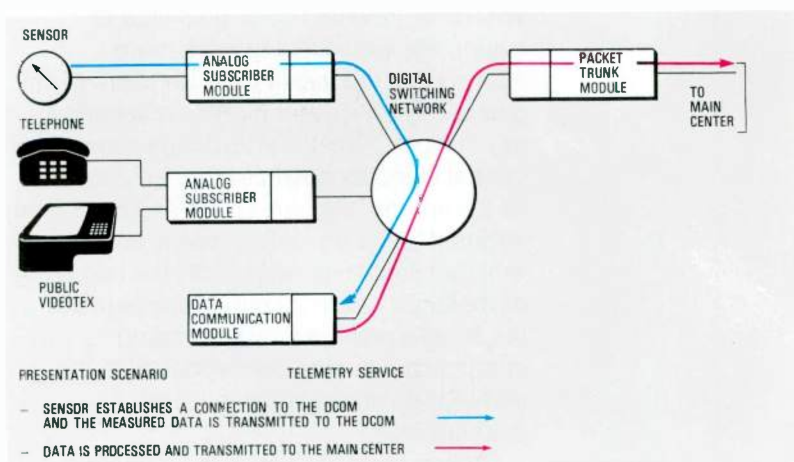


Figure 3
Telemetry service using data communication module.

Data Communication Module

Incorporated into the ITT 1240 exchange equipment on the stand is DCOM (data communication module) that allows a range of data transactions to be demonstrated. The data communication module is able to receive data into its database from a variety of inputs. Data can be accessed through a number of terminals, including videotex and new generation teleprinter. In this way the advantages of an integrated voice and data network can be discovered at first hand.

Additionally, a remote telemetry sensor feeds data automatically to the DCOM. The stored data can be accessed via terminals with visual display or printout facilities.

Typical scenarios showing the application of the data communication module to telex-mailbox, information, and remote telemetry services are shown in Figures 1, 2, and 3.

ISDN position.

Public Videotex Terminal

SEL's public videotex terminal answers questions and supplies information via the new communication service, videotex. Wherever travelers seek guidance or customers would like to have more information, the public videotex terminal can give the answers at the press of a button, day or night. All of the knowledge stored in a central videotex database can be displayed on the screen; the user retrieves the desired information via an alphanumeric keyboard with function keys that simplify the operating procedures. Up to 20 different images on the screen provide exact operating instructions and the connection with the videotex database is established automatically.

Charge rates are set by the videotex terminal subscriber. Any information retrieved from the videotex system for which there is a charge is metered separately and substracted from any remaining credit. Credit is displayed on the screen and the user notified when additional coins need to be inserted. The terminal is programmed such that certain information is available free of charge, simply by pressing the information button.

The terminal, selected as an example of good industrial design at the Hanover Fair, is arranged so that the screen, coin slots, and all operating elements can be reached easily by adults and teenagers, as well users in wheelchairs.

DPS 25 Packet Switch

The fast evolution of computer technologies has resulted in a steadily increasing demand for data processing and exchange of digital information between data users. It will be some while before all of these services can be incorporated into the evolving ISDN, for example by using the packet switching capability of ITT 1240. Thus there is still a demand that must be satisfied for sophisticated data communication facilities that operate in parallel with the public switched telephone network. Such a system must provide economical, flexible, and high quality connections between data sources and data users. The DPS 25 packet switching system fulfills these requirements in a reliable, maintainable equipment suitable for unattended operation. The packet switching technique, offering substantial economic and performance advantages over conventional circuit switched techniques, has been accepted worldwide for both private and public data communication networks.

The DPS 25 network consists of two functional entities: switching nodes and the network control system. The switching

Public videotex terminal.

node is implemented by group units that perform switching and communication functions for a dedicated group of lines. These handle the logical and physical connections to users and between switching nodes, and handle various specific procedures and convert them into a standard internal procedure. In addition the group unit performs the actual packet switching; each can handle up to 16 synchronous or 32 asynchronous user lines, varying from 50 bit s^{-1} to 64 kbit s^{-1}, depending on throughput. For large configurations special purpose group units are assigned to one type of user procedure. N + 1 combinations of group units can be configured for security, with switchover controlled by a management unit.

The standard DPS 25 system provides the following connections:

- CCITT X.25 packet synchronous interface from 2.4 to 48 kbit s^{-1}, single or multiline
- CCITT X.75 network to network connection
- CCITT PAD (X.3, X.28, X.29) supporting standard asynchronous terminals, from 50 baud telex to 1200 bit s^{-1} teletype
- IBM 3270 intelligent emulation
- IBM 2780 intelligent emulation.

Node control is performed by signaling functions and executive functions. Signaling functions provide group units with the information for establishing user routes. The executive functions monitor node operation and transfer data between units and network management centers; data exchanged includes program load and dump, continuous checks and reports, statistics, and billing data. Depending on node size, signaling and executive functions can be located in the same or separate units. A dual flexible disk drive is used by the executive functions for program, test, and diagnostics storage.

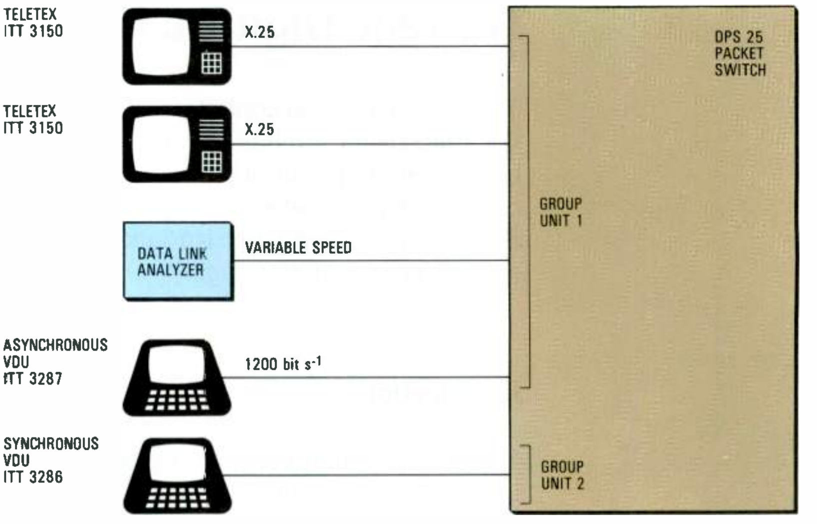


Figure 4
DPS 25 packet switching network at Telecom 83.

DPS 25 packet switch.

The DPS 25 stand demonstration configuration is shown in Figure 4. Two group units are used to connect synchronous and asynchronous display terminals and teletex terminals. System operation is monitored by the data link analyzer.

ITT 1240 Digital Exchange

The fully distributed control structure of the ITT 1240 Digital Exchange gives unprecedented flexibility in exchange configuration. Local and toll applications are covered over a wide size range, with smooth growth at any stage.

Introduction

System 12, the largest development project in ITT's history, is now a proven, successful product operating with live traffic in several countries. The ITT 1240 Digital Exchange takes advantage of the latest developments in microelectronics to create an architecture that enables control to be distributed between a multitude of individual microprocessors, eliminating a large central processor and allowing processing power to be extended in small increments. The heart of this structure is a unique digital switching network that responds to in-channel commands to set up connections for interprocessor communication and exchange pathways. The modular design, with a low count of different types of printed board, allows a wide range of application, both in the traditional network (rural, metropolitan, toll, and gateway) and in ISDN and business systems. Extensive use of LSI and hybrid technology has resulted in an exceptionally compact equipment layout of high reliability.

Smooth growth in small increments can be made at any stage to accommodate increasing traffic and more lines and trunks. Figure 1 shows the generic exchange configuration with terminal modules for a variety of services. The introduction of new services as they arise in the evolving ISDN is simply a matter of adding new terminal modules. Each terminal module includes its own control element employing a microprocessor; auxiliary control elements, again using microprocessors, are provided for communal functions.

At Telecom 83, the ITT stand has ITT 1240 as its hub, both physically and functionally. In the section on integration of services in this issue the central role of ITT 1240 is demonstrated in connecting a range of equipments and services. A digital trunk connection is made to a further ITT 1240 Digital Exchange on the BTM stand.

Digital Switching Network

The digital switching network establishes digital paths between exchange control elements. Each path is set up by commands

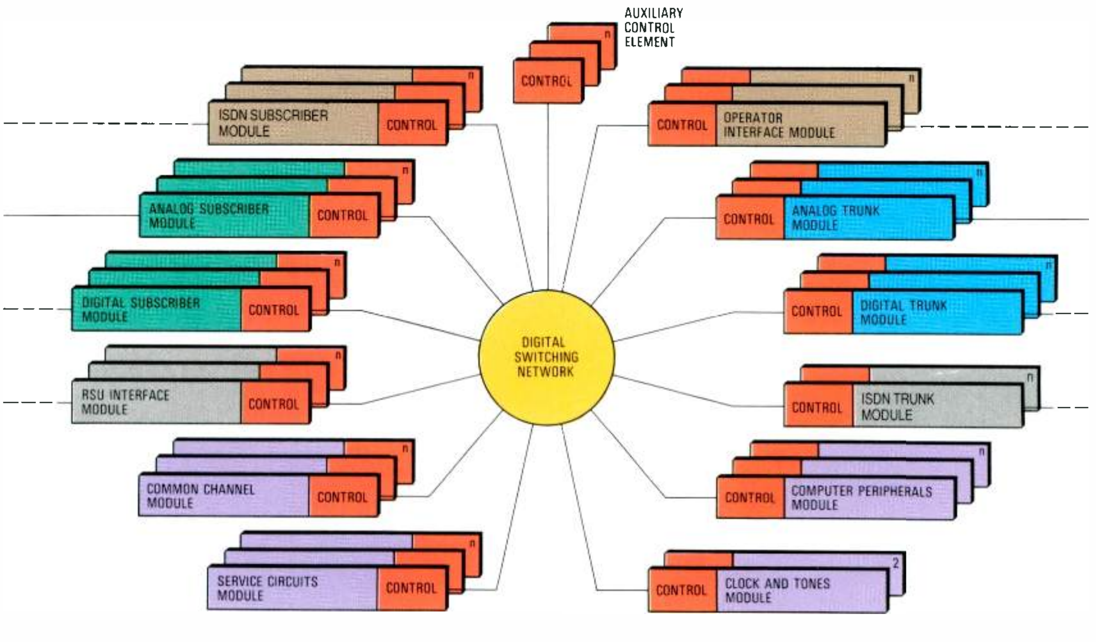


Figure 1
Architecture of the ITT 1240 Digital Exchange showing a range of terminal modules connected to the digital switching network via standard interfaces. Control of the network is distributed to the control elements of these modules and the auxiliary control elements.

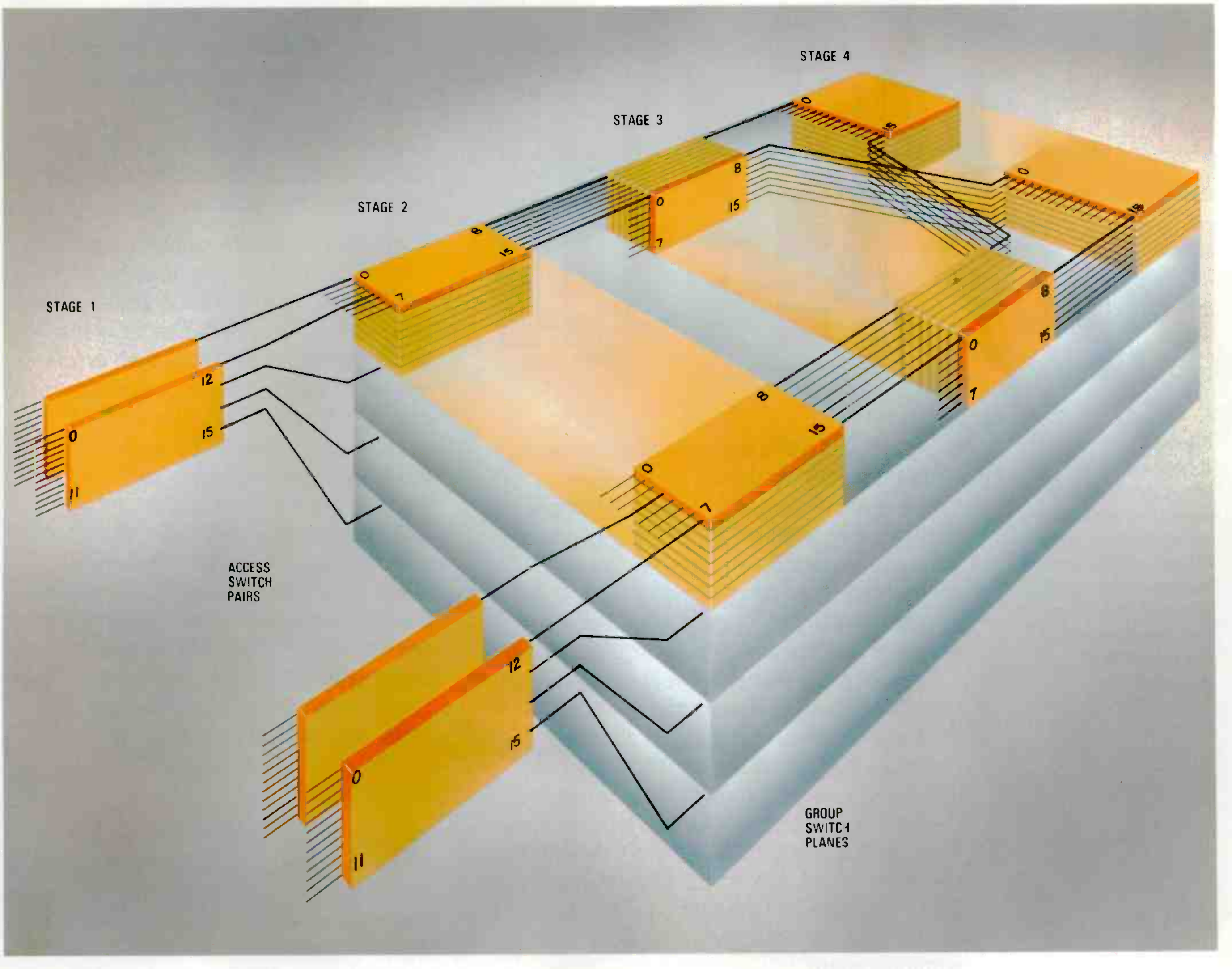


Figure 2
At the heart of the ITT 1240 – the unique digital switching network composed entirely of identical switching elements. This illustration shows the folded topology that allows up to four independent planes of 16 groups. Each group provides connections for 32 pairs of access switches, and each access switch pair provides 12 duplicated 32-channel PCM links for the connection of terminal modules.

sent along the channel from the originating control element; each command sets up the path through one stage of the network. Figure 2 shows the structure of the digital switching network, which is composed entirely of identical plug-in 16-port digital switching elements. A port consists of one incoming and one outgoing 32-channel serial bitstream at 4.096 Mbit s^{-1}.

A path is set up by one, three, five, or seven commands, according to the number of stages required to establish the connection (Figure 3). At each stage the switching element sets up a connection either to a port specified in the command or to an outgoing port selected by the digital switching element itself. A blocked path attempt is signaled automatically by a negative acknowledgment signal returned in channel *16* to the originating control element (Figure 4). The large number of possible paths for any given connection results in a virtually nonblocking switch.

The digital switching network can be equipped in two, three, or four group switching planes, accessed via the first switching stage, to provide the required traffic handling capacity.

The digital switching element is composed of 16 identical custom LSI switch ports, each an *n*-MOS circuit using 11500 transistors on a chip 5.9 mm square. The port is divided into nearly independent receive and transmit parts. The receive part synchronizes the incoming digital link, keeps track of port and channel status, and supports bus interactions between ports to set up, hold, and clear down paths. The transmit part receives a word from any receive side, performs a time switching function by storing the word in the output memory associated with a particular outgoing timeslot, carries out a first free channel search, outputs to the digital link, and supports bus operations.

Control Structure

Modularity of both hardware and program elements ensures that ITT 1240 is 'future safe' in the face of advances in hardware

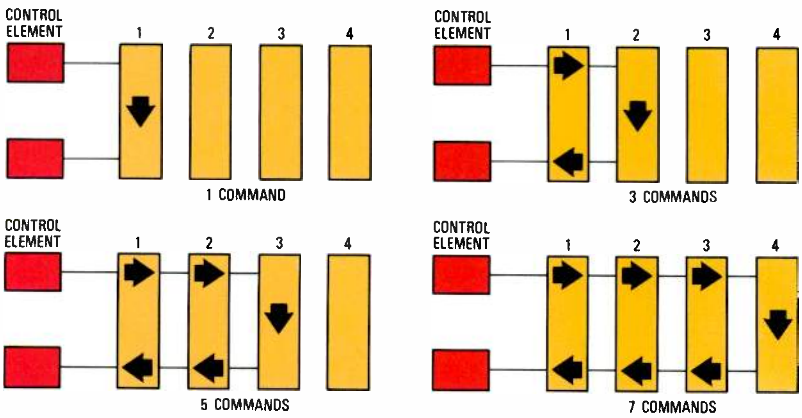


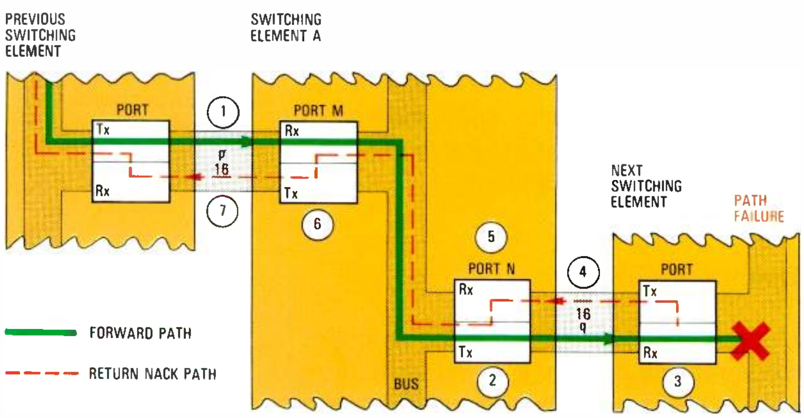
Figure 3
A path is set up through the digital switching network by commands sent from an originating control element. The number of commands depends on how many stages are needed to establish the connection.

technology. To this end, generic interfaces, finite message machines, and device handlers are employed in implementating the programs. In addition, other state-of-the-art techniques such as structured programming, a high level language, and review mechanisms have been used to enhance program modularity and reliability.

Control element hardware is divided into terminal control elements and auxiliary control elements, using identical 16-bit microprocessors based on the Intel 8086, and semiconductor memories of up to one megabyte capacity. A typical allocation of program functions to the control elements is shown in Figure 5. The main functional areas are: operating system, telephonic support, call handling, maintenance, and administration:

- The operating system provides basic support for execution of the application programs, performing such functions as intermodule communication, scheduling and timing of processes, and access to peripheral units. Operating system functions are distributed in modules as required and include a nucleus to administer data areas for processes, time services, input-output, and autonomous recovery functions.
- Telephonic support functions deal mainly with accessing and managing hardware devices, as well as signaling and charging.
- Call handling consists of two major functions, call set up and release, and call service and translation.
- Two types of maintenance function, centralized and autonomous, have a significant part in the program structure. Autonomous maintenance includes control element recovery from errors related to a single process and errors detected by checks built into an application program. These errors lead to the single process being aborted. Another autonomous maintenance feature is switchover between active/standby auxiliary control elements. Messages not accepted by the active element are automatically rerouted after several retries. Centralized maintenance deals with less critical functions such as coordination of routine and diagnostic tests, disabling of hardware security blocks, and initialization and verification after repair.
- Administrative programs provide a full range of features for automatic control of the exchange, including overload control and network management. Functions include addition and deletion of subscribers, addition of subscriber features, and changes to the directory number to equipment number translation tables. Furthermore, trunks can be added or deleted, new routes defined and routing tables changed accordingly, and charging parameters altered. Measurement programs are based on local data collection in auxiliary control elements performing call control.

Figure 4
Method of propagating NACK (negative acknowledgment) status information 'backwards' through the network to the terminal that originated the path.



Terminal Modules

The ITT 1240 consists of a variety of terminal modules connected through the digital switching network. Each module consists of two parts: terminal and terminal control element. Each type of module performs a different task, such as handling analog lines, analog trunks, digital lines, or digital trunks. A typical terminal module is shown in Figure 6.

All terminal control operations are performed by the microprocessor and memory. Each exchanges messages with other microprocessors in other control

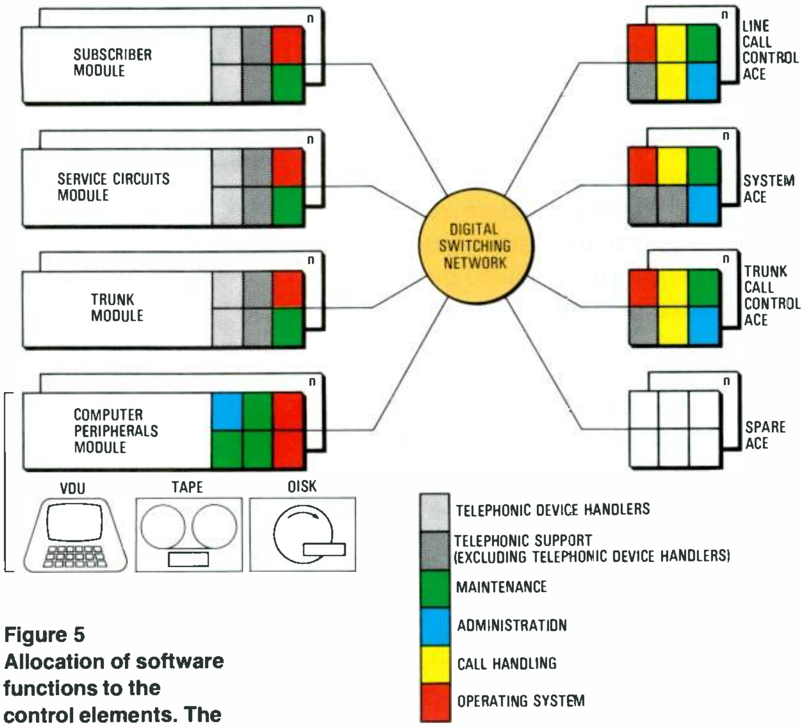


Figure 5
Allocation of software functions to the control elements. The software distribution shown only applies to a particular exchange configuration; software may be allocated differently in other configurations.

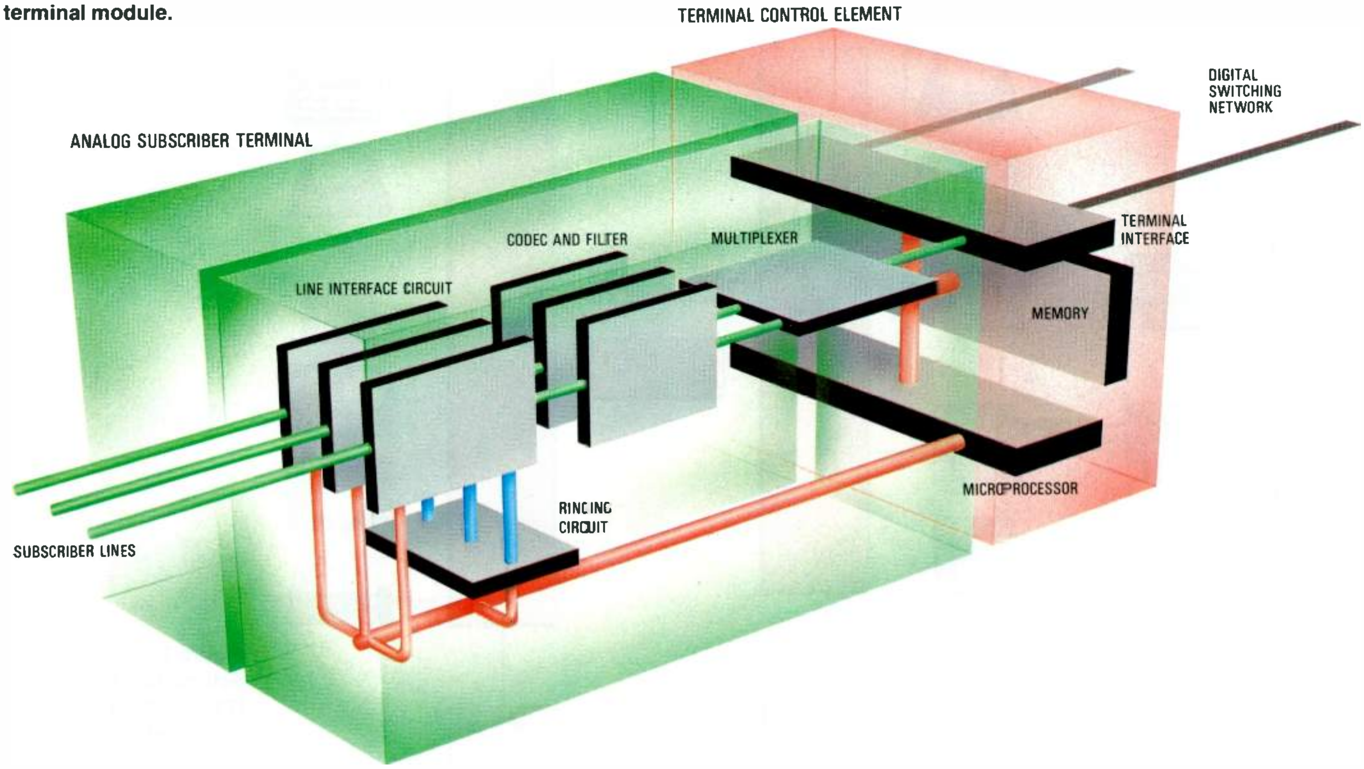
elements, via the terminal interface and digital switching network, to perform call processing, maintenance, and administrative functions, thereby eliminating the need for dedicated communication facilities. This feature, combined with a standard interface between the terminal modules and digital switching network, facilitates architectural and technological evolution within terminal modules with virtually no impact on the rest of the system. Nonrepetitive call processing functions and various other tasks are performed by auxiliary control elements which do not control any terminals. Thus an auxiliary control element consists of only a microprocessor, memory, and terminal interface. In common with the exchange terminal modules, its interface with the digital switching network is through two digital links.

The most important telephonic functions are grouped into seven modules: analog subscriber module, analog trunk module, service circuits module, digital trunk module, clock and tones module, common channel module (for CCITT No 7 signaling), and an operator interface module.

Man-machine and processor peripherals are handled by a separate computer peripherals module which incorporates a Winchester disk, reel-to-reel magnetic tape, low speed printer, visual display units, and alarm panel.

For reliability, the computer peripherals module and the clock and tones module are duplicated. Depending on requirements and the traffic load of large exchanges, several pairs of computer peripherals modules can be provided. A traffic-engineered redundancy concept is also used for the common channel module and service circuits module. The configuration is so arranged that even under failure conditions an acceptable grade of service is

Figure 6
Typical ITT 1240 terminal module.



maintained. For other modules, the ITT 1240 distributed control concept is based on the use of small groups of subscriber lines or trunks such that usually no duplication or redundancy is necessary to meet the reliability criteria. Additional duplication or redundancy can be provided at the request of an Administration.

Operations and Maintenance

Efficient exchange operation is brought about by providing all the facilities for day-to-day supervision, fault location and recovery, and exchange extension and reconfiguration. Maximum benefit has been taken of the inherent advantages of digital technology and distributed control by incorporating operations and maintenance features for the most part right into the equipment. Maintenance personnel communicate with the system using a man-machine language based on simple procedures and easily understandable messages.

The system automatically analyzes exchange or network faults, protects the system, identifies the fault, and initiates alarms. If necessary, maintenance personnel can request any diagnostic routine and can observe a given line or equipment for a certain period, for example to detect incorrect charging.

Traffic and performance measurements are facilitated by automatic collection of exchange data for each line group, individual call handling device, or processor. Maintenance personnel simply specify the measurement schedule and request the type of analysis to be performed.

Exchange management is based on functions which are all called by maintenance personnel, usually after the necessary measurements have been made. Examples are the addition of trunks to a route or a change in the charging scale.

Operations and maintenance facilities provide a wide range of measurements to help in network management; the results of these measurements are constantly analyzed and any corrective action, such as rerouting traffic, taken automatically.

The ITT 1290 Operations and Maintenance Center supports the trend of Administrations to rationalize activities in this area, and is particularly suited to ITT 1240. Centralization enables more emphasis to be given to network maintenance. Other advantages include economic provisioning of spares and test equipment and improved coordination between departments. In addition it ensures that exchange and network status reports are accurate, complete, and up to date. The ITT 1290 structure consists of two distinct communication networks, alarm links and dedicated man-machine communication links, as shown in Figure 7.

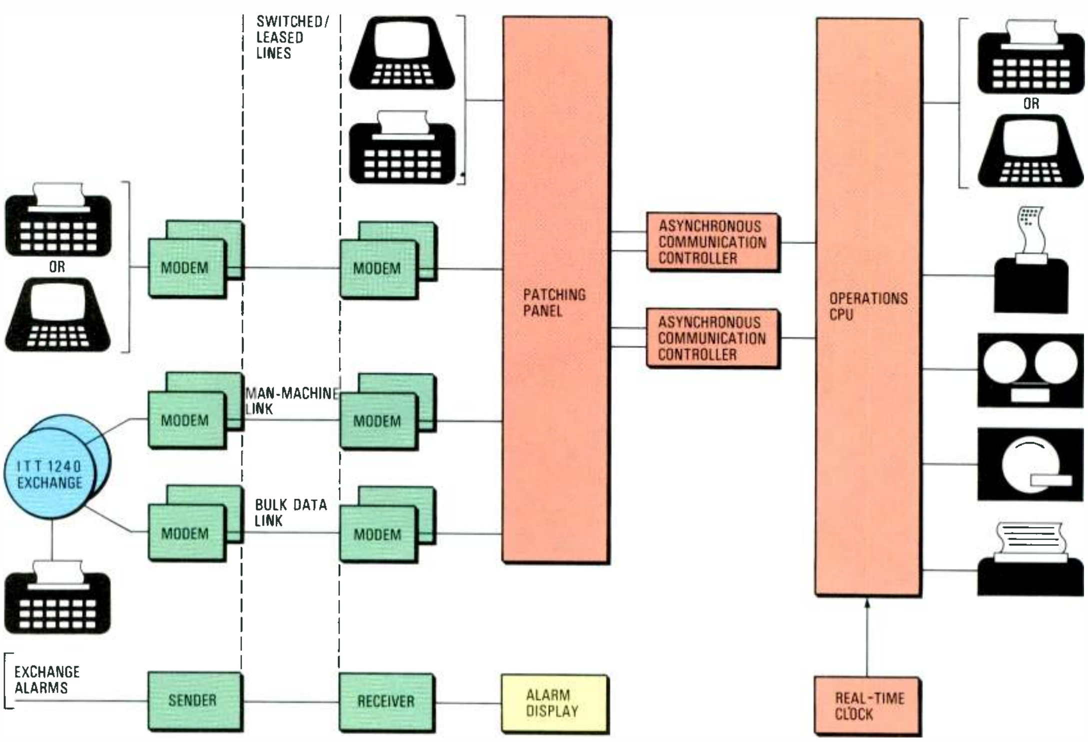


Figure 7
Schematic of the ITT 1290 Operations and Maintenance Center.

Exchange Applications

The ITT 1240 covers the full range of local, tandem, and toll exchange applications from the smallest remote subscriber unit to the largest local or toll exchange of more than 100000 lines or 60000 trunks. In addition, the smallest exchange type can be expanded easily and economically to the largest size using standard hardware modules and program elements. This capability enables ITT 1240 to be applied in various configurations for independent or dependent exchanges, including remote operation, to fit every network planning requirement.

For local exchange applications the ITT 1240 can be configured as a small, medium, or large size independent exchange incorporating its own maintenance and administration facilities, as a small exchange relying on a parent exchange for maintenance and administration, or as a remote subscriber unit providing service for up to 480 subscriber lines.

Independent local exchanges are designed to cover both individual and multi-exchange network applications. They provide a full range of maintenance and administration features, including the possibility of remoting man-machine communication terminals or connecting the exchange to an ITT 1290 center. Applications extend from large metropolitan centers down to small stand-alone rural networks, including mixed local-tandem exchanges.

The ITT 1240 remote subscriber unit is a concentrator for connecting remote subscribers to a parent local ITT 1240. It provides subscribers with the same features and facilities as a local subscriber directly connected to an independent ITT 1240. It is an integrated part of the parent exchange, providing full call handling, maintenance, and administration features. Connection to the parent exchange is via one or two 2 Mbit s^{-1} PCM links. The basic module provides for up to 128 subscriber lines. Up to four modules can be colocated, and up to eight can be separately located in a multidrop configuration.

The ITT 1240 is applicable to local and toll exchanges. For toll applications the design of the analog and digital trunk modules accommodates all possible conditions: physical 2-wire or 4-wire analog interfaces, many different signaling systems, a variety of transmission plans, and a mixed analog

Man-machine communication facilities for ITT 1240 are easy to use by installation, maintenance, and traffic administration personnel.

Number of ITT 1240 equivalent lines ordered at July 1983

Country	Equivalent lines	Exchanges
Belgium	890660	149
Mexico	578518	approx 350
Germany	14400	4
Denmark	97860	29
Italy	112680	35
Finland	27860	approx 19
Spain	532906	approx 71
Venezuela	143000	20
Nepal	23750	18
Philippines	8000	4
Taiwan	1920	1
Norway	560000	approx 220
Korea	2000	1
China	200000	approx 45
TOTAL	3193554	approx 966

ITT 1240 digital exchanges handed over

Administration	Exchange location	Type
RTT	Brecht, Belgium	Local
DBP	Stuttgart, Germany	Toll
DBP	Heilbronn, Germany	Toll
Telemex	Mexico City, Mexico	Evaluation exchange
RTT	Namur, Belgium	Local
DBP	Wuppertal, Germany	Local
DBP	Hueckeswagen, Germany	Local
SIP	Bologna Righi, Italy	Local
CTNE	Salamanca, Spain	Local
CTNE	Spain	Model exchange

The ITT 1240 Digital Exchange.

ITT 1240 digital operator position which provides a wide range of facilities to assist the operator and provide comprehensive management information for Administrations.

and digital transmission environment. Short distance calls and long distance calls with echo, trunk testing strategies, special services for each Administration, and the impact of failure on costly trunks can also be taken into account. Toll exchanges are configured from the standard range of ITT 1240 modules; a few representative examples for toll applications are:

- Digital trunk module, each interfacing with one 32- or 24-channel digital trunk working with channel associated or common channel signaling. Digital echo suppressors can be equipped for international toll exchanges.
- Analog trunk module, each providing for 30 analog trunks using either channel associated or CCITT common channel signaling. Optional echo suppression and inband signaling equipment can be included.
- Announcement module which supplies digitally generated announcements or connects lines to existing analog announcement machines
- Trunk test module which connects trunk testing equipment to the digital switching network to provide trunk testing facilities in conjunction with the standard computer peripherals module, service circuits modules, and analog or digital trunk modules.

ITT 1240 Digital Operator Position

Despite the continuing increase in direct-dialed calls and the greater versatility of modern stored program controlled exchanges, operator intervention remains an essential service in any telephone network. However, no longer do operators simply connect calls; they now provide services such as charge notification and person-to-person calls.

The ITT 1240 digital operator position is designed to bring the power and flexibility of digital microprocessor technology to the aid of the operator by eliminating tedious, manual tasks and keeping extensive call records. As a result the operator is freed to provide more rapid, comprehensive, and accurate assistance to subscribers. The traditional 'paper ticket' has been replaced by 'computerized tickets' which appear on the VDU screen and are filled in via the keyboard; these tickets can then be recalled immediately if there is a subsequent query. Every action related to every position is automatically recorded by the operator position, helping to avoid costly errors, preventing the loss of billable charges, and virtually eliminating charging errors.

As well as handling subscriber traffic, the digital operator position offers tools for modern, computer-supported exchange management. To increase efficiency, management personnel can request a wide variety of management information, carry out organizational and service-related assignments, and communicate directly with operators. An interactive menu technique makes these tasks very straightforward.

A typical ITT 1240 digital operator position consists of the position desk housing the electronic equipment, a microprocessor-controlled position desk controller, keyboard for data and command entry, VDU, and a lightweight headset. Two basic configurations are possible. In the integrated version it links directly with an ITT 1240 digital exchange, to which it is the natural complement in view of the operator position's use of digital technology and distributed control. A stand-alone configuration is also available for linking with one or more digital or analog exchanges.

A number of operator positions can be grouped into an operator center which consists of traffic positions, supervisor positions, service observation positions, training positions, and a management terminal. As all the positions are identical, specific tasks are assigned by management commands which fix the functional characteristics of each position in software tables. Tasks can easily be reassigned should this be necessary.

These features ensure that the ITT 1240 digital operator position meets its main objectives of improving the quality of service to subscribers, making the task of the operators more interesting, and providing facilities that enable Administrations to improve efficiency and overall network quality.

Office Communications

Office communications and automation are vital in a technological world where the success of a business depends on effective handling and transfer of information.

Introduction

A revolution is taking place in the office. Already word processors, facsimile machines, telex networks, data terminals, and advanced telephone facilities have contributed to higher productivity. Now the emphasis is on integration, using intelligent PABXs or communication controllers to connect a wide range of new office terminals for data and text applications. The future office will be supported by display terminals, advanced teleprinters, fast facsimile machines, high-capacity storage devices, other special processors, and printout devices.

It will be possible to transfer text, data, and documents between offices and between people in the office – instantly and reliably. Stored data will be immediately accessible, reducing the need for paper. Powerful word processing, data processing, and graphics systems will be to hand, at the user's desk.

New skills will need to be developed to take full advantage of the possibilities offered by integrated office systems. Inefficient traditional methods of communication will have to be discarded in favor of improved facilities, relying on direct entry of and access to information via human interface devices to various systems. Less dependence on paperwork will be the inevitable outcome – eliminating the accumulation of outdated documents and speeding access to and transfer of information. More reliance will be placed on the intelligence of systems, their user-friendliness, and good ergonomic design in the quest for a better working environment.

For those who choose to stay ahead, the office of the future is already here, confirmed by ITT's display at Telecom 83 which clearly demonstrates the powerful features of a wide range of state-of-the-art equipment. In fact, a substantial proportion of the stand at Telecom 83 is dedicated to office automation and communications equipment, an indication of its importance in future telecommunications and a demonstration of the potential of the automated office environment.

Functionally the equipment falls into three groups. The first group consists of a data communication network, directly linked via the STC stand to a central computer system with large data files. The heart of this system is the ITT 3809 communications controller, which interconnects and controls a wide range of display terminals, programmable workstations, and printers. The second group consists of the ITT 5200, ITT 5300, and ITT 5500 business communication systems which are connected to the integrated stand network by the ITT 1240 Digital Exchange. These digital PABXs serve a variety of telephone subsets and key systems, including the Uniphone, Intermat, Executel, and Digitel 2000.

Finally there are terminals for non-voice services: the ITT 3000 teleprinter, in two versions offering either modular or integrated equipment construction, the ITT 3535 facsimile machine, and the ITT 3150 teletex terminal. Again, these units are part of the integrated stand network.

Programming for Information Processing

Today not only is there an ever-increasing use of electronic equipment in businesses but also the equipment is increasingly user-programmable, giving greater flexibility in the way it can be used. Examples are easy to think of: telephones which store commonly used numbers; exchanges that are reprogrammed as extra lines are added; word processing systems; terminals connected to mainframe computers; microcomputers in the office; telex machines that allow standard headings, messages, and footnotes to be stored.

As a result, people are increasingly coming into contact with programs at work;

at the same time, more and more programs are being written to enable companies and individuals to use all this equipment in the most effective ways for their particular applications.

Recently there has been a trend towards easier access to computers and to their programs. The old days of a central computer locked away in a secure room and accessed in batch mode via punched cards or magnetic tape and high speed printer output have gone. We now have not only thousands of terminals with telecommunications links into mainframes but also distributed departmental computer systems and even desktop microcomputers for the individual. Table 1 shows the different levels of computing resources with some of their main characteristics. The increasing availability and economy of computers are now allowing them to be used by many more people.

Programs are also being developed to help people to use the equipment without becoming programming experts. Computer hardware is only able to deal with simple instructions based on binary logic, but programs can use these instructions to convert complex commands into all necessary basic components. In this way a simplified form of English can be used for commands with the programs doing the tedious job of interpreting their meaning into a sequence of basic instructions. Because computers can process millions of instructions per second, the time taken for these translations is rarely noticed by the user. Examples of English-type languages for computers can be seen in database enquiry systems and also in microcomputer spreadsheet packages (where the commands are usually abbreviations).

These two trends allow many more people to use computer programs and to use them more easily. This provides the companies in which they work with a great opportunity to improve productivity: users with access to computers can store large quantities of data in logical formats, perform rapid analyses, and prepare information for transmission. However, unless the use of computing is properly structured it can also be a great waste of time and resources, especially when users do not have much training. Certain guidelines should be followed:

- avoid duplication of work
- communicate results to shared files so that the same up-to-date data is used by everyone in the organization
- document work so that others can use it (or even the original user after a space of several months)
- structure programming so that when changes or enhancements are needed the whole program does not have to be altered
- ensure that backup copies are always available in case of loss or damage to the original.

The last two points can only be learned by experience or formal training, but the first three can cause considerable harm to the work of a company, as opposed to the individual, if they are ignored. This problem can be dealt with by providing programs to link users together.

Table 1 — Different levels of computing resources within a corporation

Type of computer	Mainframe	Departmental minicomputer	Desktop microcomputer
Location	Central site	Department	User's desk
Controller of resources	Data processing manager	Department manager or delegate	User(s)
Usage	Corporate data storage and analysis plus large computing tasks	Particular departmental usage (e.g. word processing or accounting system)	User's own requirements (e.g. memo writing or analysis of experimental results)
Access	Via terminals and telecom links	Terminals and/or system may be in a nearby room	Terminal and/or system on desk
Programs	Expensive and sophisticated; often for 'experts' to use	Usually dedicated to the department's functions and connected to the central site	Often easy to learn and use

The different types of computer and how they are used at various levels in an organization have already been pointed out in Table 1. In order to ensure that work is not duplicated at the different levels, that reports and analyses are not based on conflicting or incorrect data, and that new data is disseminated, it is vital that companies have links between these levels so that an efficient and timely flow of information can take place between them. ITT's data systems divisions already have available equipment and programs that provide such links. The ITT 3290 workstation and ITT 3480 distributed data processing system are two new ITT data products specifically designed with these communication requirements in mind.

Present products already incorporate programs that allow integration of the computing done at the personal, departmental, and corporate levels. However, two further steps are needed to complete the integration process. The first of these is to provide programs that not only allow integration but provide a structure that reinforces it; this will ensure that data integrity does not rely totally on the user understanding or even remembering when data transfer or updating is required. Three features are necessary in any program developed for this purpose:

- common user interface with the same command syntax and screen display whether the user is talking to a personal computer, departmental system, or mainframe
- automated process for transferring data between levels on a regular basis as well as at other times specified by the user
- features for the protection and validation of data at different levels, including password protection.

Second, programs need to be developed to link data, text, and voice communication equipment together to provide common access to all equipment. Such programs will result in better local networks that link together data and text equipment over a defined geographical area. In this way existing hardware can be used but its value is enhanced because it will be possible to link it to all other equipment in the office. This integration requires a great deal of work to handle the protocols of machines that were designed originally for very different purposes. However ITT units have already invested heavily in such work and the first products with this capability will be available soon.

Data Communications Network

The hub of the data communications network on the ITT corporate stand (Figure 1) is the ITT 3809 communications controller, which is linked to the STC stand to demonstrate interoffice communication. The ITT 3809 and its smaller brother the ITT 3805 communication processor, control the communication for a variety of workstations and terminals, both directly and via the ITT 3284 and 3286 terminal controllers. They also provide immediate access to a large central computer system with many application programs and extensive files.

The equipment on show is able to demonstrate the following facilities:

- word processing
- message storage, distribution, and retrieval
- data storage and retrieval
- communication of displayed messages and printed documents
- graphics
- access to host data processing
- remote (distributed) data processing
- personal computing
- management control
- program generation.

User friendliness is a key word in the design of both hardware and programming for office systems. Frequently such equipment is in constant use in a long-term working environment where the comfort of the individual depends on good ergonomic design and careful attention to human factors. A well designed terminal supported by well designed programs and communication protocols promotes efficiency and a good working environment for the user.

ITT 3805/9 Communications Controllers

The ITT 3805 and ITT 3809 are modular, programmable communications control systems for networks which are hosted by IBM 370, 30XX and 43XX computer systems or equivalent plug-compatible processors. In addition to front end processing they can be used for remote communication processing.

The most powerful model, the ITT 3809, can support up to eight host processors simultaneously, IBM and non-IBM terminals, local peripheral input-output devices, and up to 512 full duplex communications lines. Its central processing unit, which contains all the control, arithmetic, and logic circuits, has a 650 ns cycle time and an execution speed of 1.27 million instructions per second. Up to 4 Mbytes of main memory can be used.

As many as eight channel interface adaptors can be included in the ITT 3809, each providing 256 subchannel or device addresses to the IBM channel. Four communications adaptors can be configured; these control data transfer between memory and the communications lines. Each communications adaptor can be connected to eight modem interface modules.

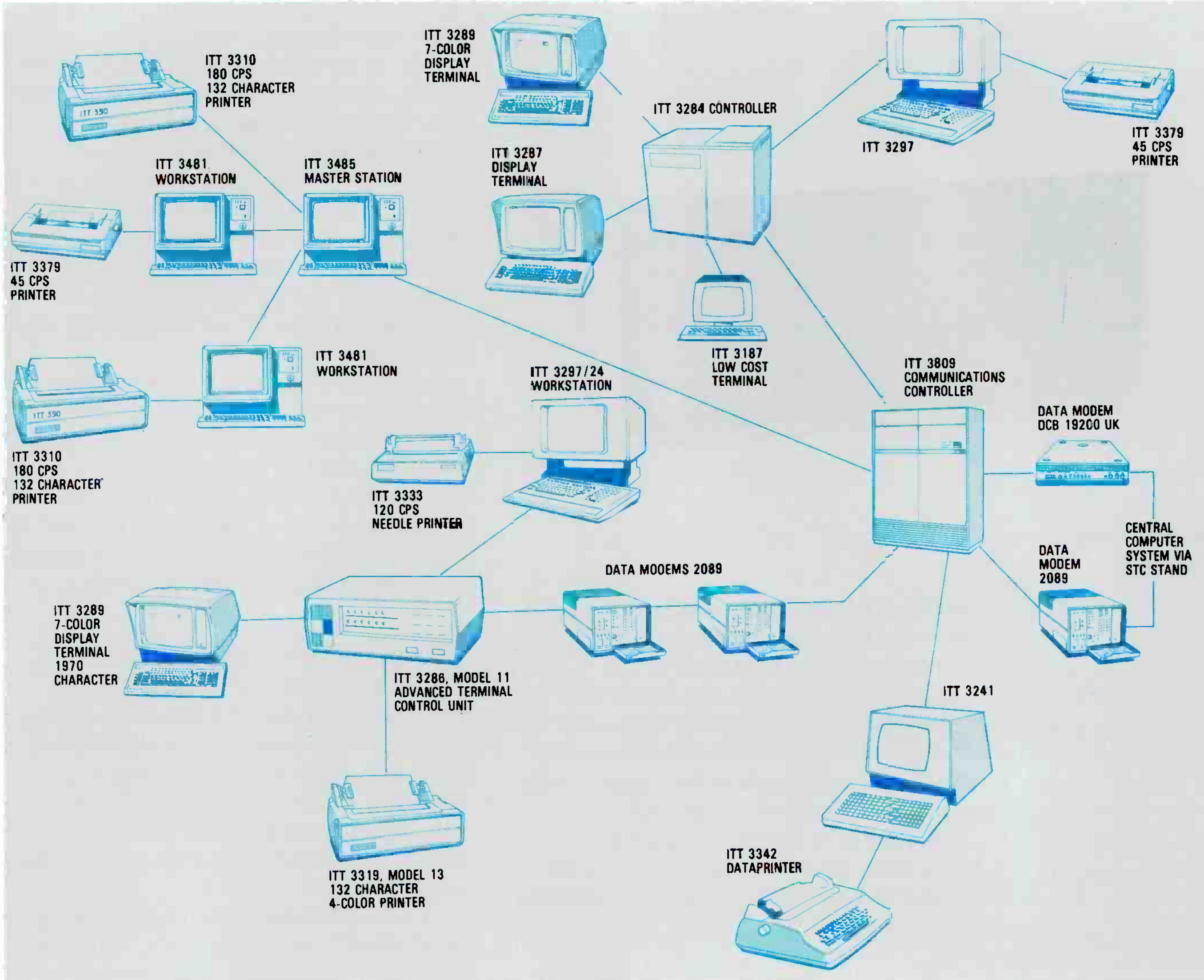


Figure 1
Office communications: data systems.

Three different types of modem interface module are available, each able to handle up to 16 lines, offering a variety of start-stop and synchronous line connections. Dial, leased, X.21, and X.25 services are supported with a maximum line rate of 64 kbit s^{-1}, but higher speeds will soon be available, aimed primarily at the interconnection of ITT 3805 and ITT 3809 systems over high speed digital circuits or satellite links.

The ITT 3805, a medium size communications controller, supports two hosts, 128 lines, and 512 kbytes of memory.

A system control console is provided with both the ITT 3805 and ITT 3809 to give local and remote command, control, and monitoring facilities. The console can be supplemented by a visual display unit.

The extensive range of available network management facilities includes:

- dynamic reconfiguration to deal with everyday teleprocessing mishaps
- line to subchannel assignment change without involving the host
- on-line testing to ensure correct operation of the network
- statistics collection
- password protection
- broadcast facilities, either for general use or to inform users of a host or application fault.

In addition, network modeling packages are available to predict processor, controller, and terminal performance.

Software for SNA (systems network architecture) users is compatible with ACF/NCP (advanced communications function/network control program).

For mixed SNA and emulation processing networks, a unique migration tool – the subarea routing manager – permits access to both SNA and pre-SNA hosts or host applications.

For the emulation processing user, the

ITT 3286 remote controller.

multiple access facility enables interactive terminal operators to select between multiple hosts or host applications; switching facilities are also available to non-polled or remote batch terminals.

For users of packet switched networks, X.25 support is available for a large variety of terminals in SNA or non-SNA environments. For circuit switched networks, full X.21 support will soon be available for SNA users, whose interactive terminals can take advantage of the short-hold-mode feature.

For the interconnection of ITT 3805s and 3809s as front end processors and remote concentrators, the trunking and routing communications networking system software (which includes application switching facilities) enables terminals to access any host in the network. The communications networking system can also handle multiple protocols and line speeds on trunks with an efficient blocking and routing mechanism.

A unique ITT feature, remote partitioned emulation processing, allows the use of remote concentrators in a mixed SNA and non-SNA environment, protecting investment in existing applications and terminals which can continue to be used while new applications are being developed under more recent access methods.

ITT 3287 visual display unit.

ITT 3284 and ITT 3286 Controllers

The ITT 3284 and 3286 are new components of the ITT 3280 visual display system. Three versions of the ITT 3284 provide for SNA mode, 3282 mode, and SNA/SDLC-BSC mode. The ITT 3286 remote controller is a smaller, economic option for terminal requirements of up to six workstations.

The ITT 3284 can be connected locally to an IBM 360/370/303X or 4300. In remote operation, via a leased or dial-up line, both versions operate at up to 9.6 kbit s^{-1} in the normal BSC or SNA/SDLC mode. All control units can be used with the ITT 3287 display units (models 5 to 8), ITT 3187 low cost displays, and ITT 3289 color displays, as well as all earlier units and printers.

Diagnostic functions and fault logging are built in; automatic testing is performed at switch-on. In addition, a capture mode can display the whole of the channel or line traffic on the screen to facilitate fault finding.

VDU Terminals

All ITT displays have standard design features to ensure user comfort and efficiency. Eye fatigue is minimized by non-glare, non-smear screens which ensure a crisp flicker-free image. Adjustable keyboards with separators between the typewriter and control keys facilitate rapid and accurate inputting of text and data.

The ITT 3287 series of visual display units can be connected to the ITT 3284 or 3286 controllers, working in the local or remote mode. Terminal and control unit can be situated up to 1500 m apart. The range consists of four models:

- 1920 character display (24 lines by 80 columns) using a 9 × 12 dot matrix
- 2560 character display (32 lines by 80 columns) using a 9 × 11 dot matrix
- 3440 character display (43 lines by 80 columns) using a 9 × 9 dot matrix
- 3564 character display (27 lines by 132 columns) using a 9 × 9 dot matrix.

The range allows a choice of typewriter or data entry keyboard.

The ITT3187 display terminal has been introduced to fulfill a marked need for high performance combined with low cost. The 12 inch CRT displays up to 1920 characters in 24 lines of 80 characters, with a 7 by 10 character presentation matrix. Two models are available with a choice of data entry or typewriter keyboards. Both the display unit and the keyboard are particularly lightweight and compact. Power consumption is also low. The design combines the benefits of the latest 3280 series with advances in ergonomics for enhanced operator comfort and productivity. The display tilts and swivels and the detached keyboard can be adjusted for height.

The ITT3289 features a seven color display which comes in three versions offering 1920, 2560, and 3440 characters. The display has a large screen with extremely high resolution. Data can be displayed in white, red, blue, green, yellow, pink, and turquoise by selecting the field attribute byte:

white:	protected, high intensity
red:	unprotected, high intensity
blue:	protected, normal intensity
green:	unprotected, normal intensity
yellow:	unprotected, normal intensity, blink
pink:	protected, normal intensity, blink
turquoise:	protected, high intensity, blink.

The seven colors can also be 'dynamically assigned', either during customization or by the operator.

In addition there is a blue status and message line. The display technology gives factory-set locked-in color convergence.

Structured color display of information can improve productivity in the office and reduce operator fatigue.

ITT 3187 low cost visual display terminal.

Printers

A variety of quality printers is offered to support each type of printing requirement. These range from low cost, simple printout

ITT 3289 seven color display.

devices to high volume line printers; they encompass word processing quality reproduction as well as specialized features such as color printing, cut sheet feeders, bar code printing, and graphics.

The printer range includes the following classes of product:

- ITT 332X fast matrix printers operating at up to 400 characters per second with full flexibility in printing from draft quality to near letter quality in multiple type fonts. Options include 4-color, bar-code, and pin-addressable graphics printing.
- ITT 333X low cost matrix printers operating at up to 120 characters per second with either 80-column or 132-column page width. They are small and light, and provide simple graphics facilities.
- ITT 336X line printers operating at up to 800 lines per minute with low noise levels and full line printer features.
- ITT 337X correspondence quality printers giving up to 55 characters per second high quality printing using the popular daisywheel technique.

All the printers include a variety of signal interfaces and controllers so that they can interwork with the whole range of ITT office communications products.

ITT 3290 Intelligent Workstations

The ITT 3290 intelligent workstation incorporates the benefits of the IBM 3270 protocol through the ITT 3280 control units – BSC or SNA/SDLC – and a significant amount of 'on-board' intelligence to carry out local tasks independent of the mainframe.

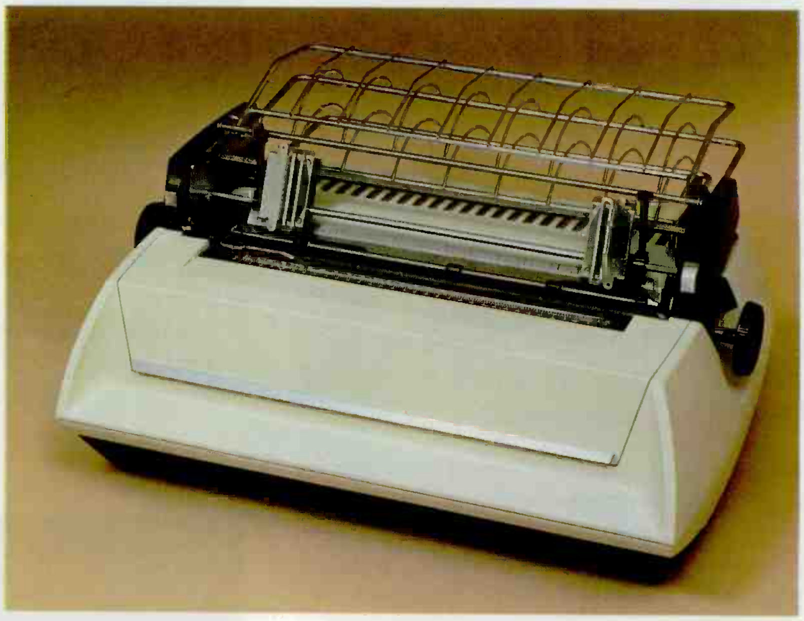
Local operations are carried out with the aid of a 2.4 Mbyte, double-sided/double-density 8 inch floppy disk drive, or a 10 Mbyte Winchester disk drive.

Additional communication can be either IBM 3270 BSC, IBM 2780/3780, or teleprinter via a secondary line port, in stand-alone mode or in clustered mode.

The Z80A processor gives 64 or 128 kbytes of random access memory and uses the popular CP/M operating system, which means it can accept and use a vast amount of 'off-the-shelf' software for stand-alone applications, including:

- Wordstar word processing
- Datastar remote data capture
- Calcstar financial modeling
- Mailmerge mail list utilization

ITT 3342 printer.



ITT 3370 printer.

ITT 3310 printer.

- Forms 2 accounting functions
- CIS Cobol programming capability – mainframe compatible.

Interaction between the workstation and the mainframe is greatly facilitated by the ITT 3290 file transfer protocol, operational in both BSC and SDLC. This feature allows the operator running a CP/M application to switch to 3270 mode in order to call up from the host a file that is needed to finish the program. Conversely, the protocol allows local files to be transferred to the host so that they become available to all users in the corporate network.

The powerful devices that go to make up the ITT 3290 workstation system, including attached files and printers, extend its capabilities far beyond that suggested by the usual concept of a 'terminal'.

Whatever the role chosen for the ITT 3290 intelligent workstation, it permits the data processing manager and the end user to take advantage of advanced microprocessor capabilities absent in traditional 3270 terminals, and to plan a system with the inherent benefits of clustered functions.

ITT 3297 intelligent workstation.

ITT 3480 Distributed Data Processing System

The ITT 3480 is a powerful 'distributed' solution to the conflicting needs of data processing managers and the end user. The system's multifunction workstations give the operator complete control and independence within the data processing environment, providing him with his own applications programs, processing power, memory, and files. On the other hand, the data processing manager's objectives are also met. The ITT 3480 provides him with an 'integrated' solution that enables corporate data and resources to be used with the maximum efficiency, while at the same time maintaining complete security. To support multi-user applications in a distributed environment, the ITT 3480 runs a sophisticated new operating system. This enables up to seven workstations to be linked into a local network in which all resources can be shared. Files, peripherals, and communication facilities are accessible to every workstation in the network subject only to the built-in security procedures.

Because they have been designed specifically for distributed data processing networks, the way in which ITT 3480 workstations access the host is much more sophisticated than that of conventional emulators. A feature called the ITT 3480 softlink allows integration of local and remote applications, and enables the user to access local files, central host, or both –

ITT 3480 multifunction workstation.

with total transparency – regardless of their location. The ITT 3480 offers a comprehensive set of emulators, including:

- remote job entry in both BSC and SNA networks
- multileaving remote job entry in BSC networks
- 3270 emulation in both BSC and SNA networks.

A wide range of possibilities is available to the ITT 3480 user, providing quick solutions to his day-to-day problems.

Host programming: The ITT 3480 host COBOL compiler (ANSI 74, Level 2) takes full advantage of existing data processing resources for the development and control of local applications.

Local processing: The ITT 3480 provides an extended version of the most popular standard programming languages: COBOL and business basic. In addition, the ITT 3480's unique 'easy programming facility' enables users to develop local applications even if they have no prior knowledge of programming.

Personal computing: Personal computing facilities are available using either the MS-DOS or CP/M-86 operating systems; both give immediate access to a full range of 'off-the-shelf' applications packages.

Word processing: Wordstar, the most widely used word processing package, has already been adapted to the ITT 3480, taking full advantage of the ITT 3480 screen attributes and keyboard functionality.

Conventional applications: The ITT 3480 also offers transcriptive and intelligent data entry, on-line data entry and enquiry, and local transaction processing.

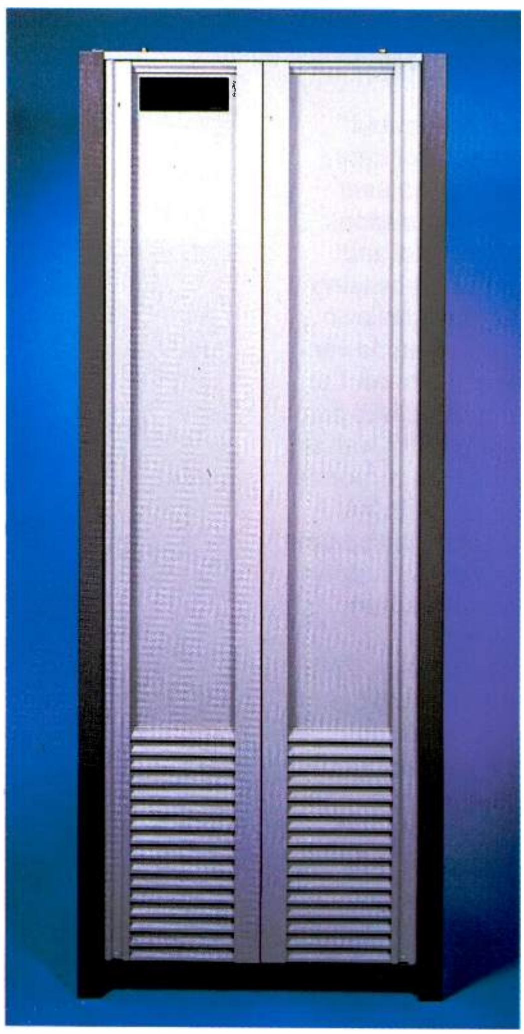
Business Communication Systems

The private branch exchange has entered a new era with the latest electronic equipment (Figure 2). Digital operation, powerful processor control, compactness, reliability, straightforward maintenance, and an unprecedented variety of features and facilities make products such as the ITT 5200, ITT 5300, and ITT 5500 much more powerful and versatile than traditional PABXs. The features offered, too numerous to list fully, include everything needed by the telephone user, the operator, the administration, and the maintenance engineer. All of these features lead to improved communication, projecting an enhanced image to outside callers and internal users alike. Features such as abbreviated dialing, conferencing, intercom, and call redirection can be made available to every telephone user. Facilities such as detailed call recording and trunk barring enable better control to be exercised over use of the telephone service.

New digital PABXs will have a considerable influence on the evolution towards integration of services; by offering a digital connection to each user, many non-voice services become available in the local area which will eventually propagate through to the public telephone network.

ITT 5500 Business Communication System

The ITT 5500 from STK is a fully digital communication system with a highly flexible modular design. By combining appropriate system modules, traditional centralized equipment PABXs ranging from 100 lines to several thousand lines, distributed



ITT 5500 business communication system.

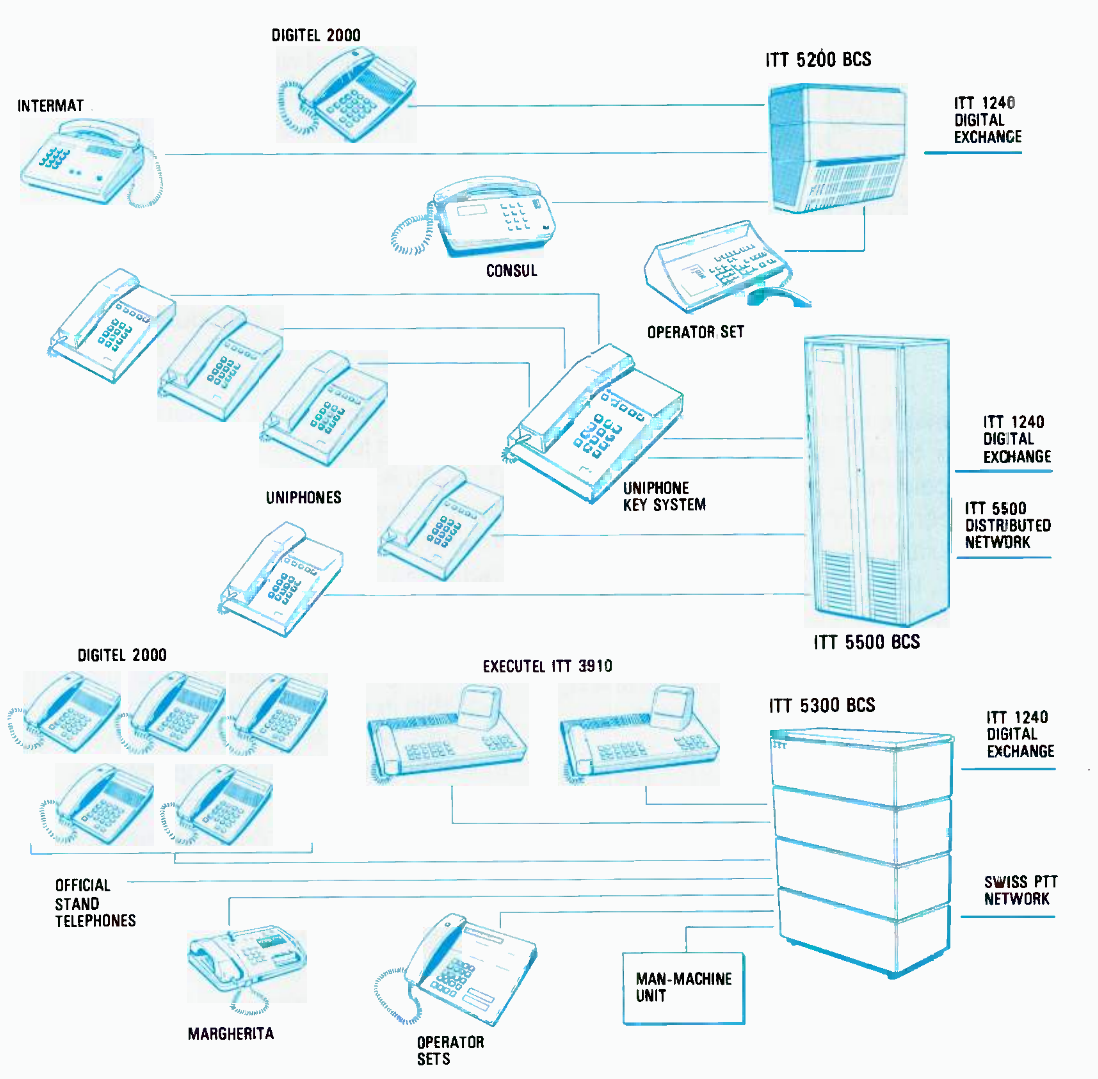


Figure 2
Office communications: business communication systems.

equipment PABXs, and private networks can be built with equal ease. The system also offers effective solutions to the integration of voice and non-voice services.

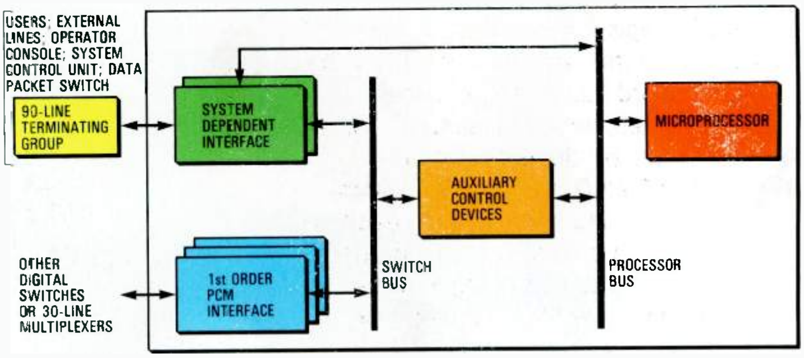
The basic building block is a small digital switch capable of switching the equivalent of eight CEPT-standard 1st order PCM systems, or 256 channels, without blocking. The switch (Figure 3) is stored program controlled using a microprocessor with optional RAM or PROM program storage. Auxiliary control devices consist of registers, generators, and special purpose preprocessing devices depending on the particular application. First-order PCM interface modules provide for connection between switches and for 30-channel line multiplexers. System-dependent interface modules connect the switch to 90-line terminating groups for the connection of users, external lines, operator console, control unit, and a packet switch.

Modular programs, as well as modular hardware, allow easy adaptation to special user requirements. For example, a signaling package may be composed of modules taken from a program module library, with the possible addition of specially designed modules. Programs are written in the CCITT high level language, CHILL.

ITT 5300 Business Communication System

The ITT 5300 is a digital PABX with a size range extending from 32 to 352 ports,

Figure 3
ITT 5500 system modules.



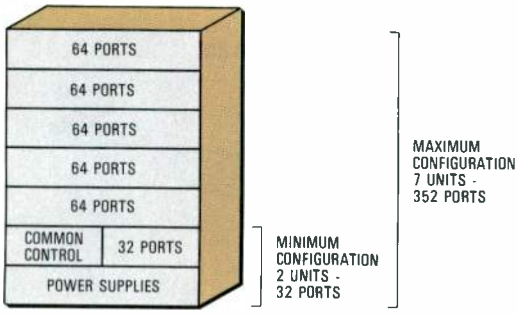


Figure 4
Modular growth of the ITT 5300.

allowing flexible configuration of extensions, trunks, tie lines, and tone sender-receivers. A comprehensive range of subscriber, operator, and system features is built in: examples are abbreviated dialing, call pick up, trunk barring, do not disturb, and automatic call recording, among many others. The ITT 5300, being digital in operation, is suitable for both present analog lines and future digital voice and data services.

The control structure is based on a central microprocessor with distributed microprocessor controllers for each group of 64 ports to control actions such as scanning and timing at port level. All control equipment, line circuits, system memory, and programs are contained in a series of modular units which are stacked vertically to form a compact equipment suite. The size of PABX required will determine the number of modules, the maximum of seven providing up to 300 telephone lines (Figure 4).

ITT 5300 business communication system.

ITT 5200 Business Communication System

The ITT 5200 business communication system from ITTA is a modular, fully digital system which uses pulse code modulation and time division multiplexing in accordance with CCITT and CEPT recommendations. Conceived for the office of the future, the ITT 5200 is easily adaptable for data communication, operation in a digital environment, networking, and access to dedicated networks. However, this versatile fully digital system can be installed today as an effective and economic PABX in present day analog environments. The equipment is available in wall mounted and floor standing versions with integral MDF and universal power supply. A compact operator console allows comprehensive control of all operational and maintenance functions, including an alphanumeric display for full call progress information.

A wide range of sophisticated features is offered, covering all the existing and anticipated requirements of today's and tomorrow's business communication systems. Special features of the ITT 5200 which differ markedly from other current systems are:

- one system can cover all size ranges up to 1024 ports
- just 13 types of printed board are used making it easy to stock a full range of spares
- training in system use and maintenance can be accomplished very rapidly, and therefore at a low cost.

The design is based on distributed processing so that even when a full size system is installed the central processing unit is only lightly loaded, ensuring that there are no overload limitations.

As already indicated, there is a maximum of 1024 ports, although the compact wall-mounted version is limited to 120 usable ports. The equipment is configured from plug-in printed boards, allowing adaptation to a wide range of specific requirements, and easy extension.

System control programming is based on advanced software technology; a well defined program structure is supported by the ITT real-time multitasking operating system 0802 and the 0802 CHILL tasking concept. The use of CHILL results in highly reliable and clearly structured programs.

Extensive facilities are available for installation, maintenance, and administration of the ITT5200 using the CCITT man-machine language. Administration and diagnostic facilities can be initiated on site or from a remote service center. This increases servicing flexibility, and will provide service centers with an important role in PABX maintenance.

ITT5200 business communication system.

Teleprinters, Facsimile, and Teletex

ITT3000 Teleprinters

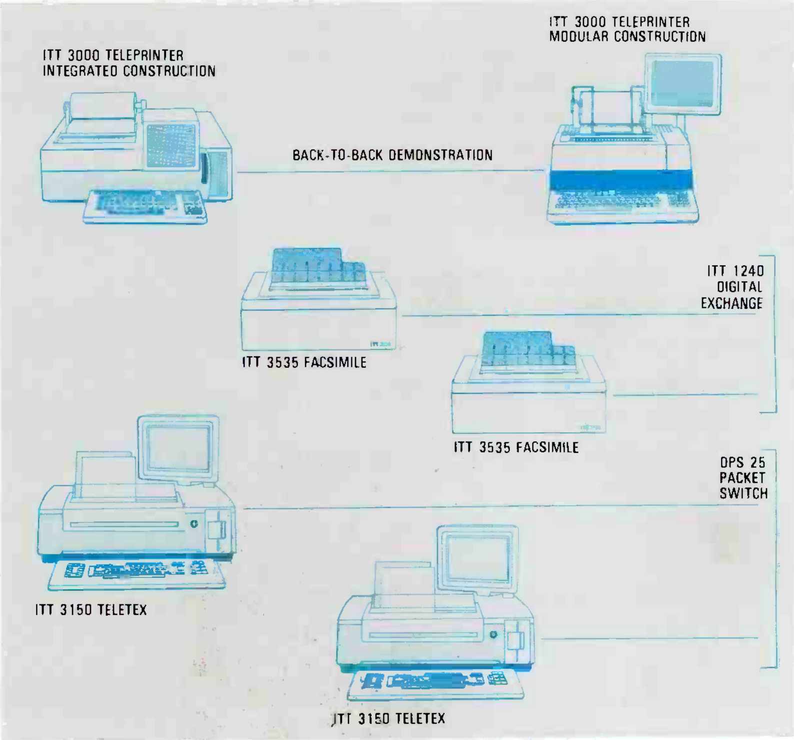
The ITT3000 family of teleprinters provides all the benefits of advanced microprocessor technology, with considerable flexibility to allow for changes in users' requirements. Using CCITT Code No 2, the series is designed to operate with domestic and international telex networks as well as private networks. High performance terminals bring word processing facilities to the telex environment. Two basic versions are available, a modular version and an integrated version. The modular version can be configured either as a receive-only printer, or a send-receive terminal with keyboard, message store, and optional display. Paper tape and disk modules can be added to all versions.

The printer operates at 60 characters per second with a 9 × 9 dot matrix print head; the ribbon cartridge has a lifetime of 20 million characters. Receive-send discrimination can be effected either by slanting print or by two-color printing. The electronically buffered rubber mat keyboard has good tactile feedback and is quiet in operation; it incorporates rollover with automatic shift insertion.

The fully adjustable display unit has 14 large-format lines, with 13 × 7 dot matrix characters. Smooth vertical scrolling allows text to be read while moving. The entry line is in the lower third of the screen for maximum visibility.

Plug-in interface modules are available for all known line signaling conditions. Answerback by means of a subscriber unit is programmable from the keyboard for a sequence of from 20 up to 32 characters. The diskette module, which has a capacity of approximately 80 000 characters, can be used for the intermediate storage of messages awaiting transmission or for recording on-line traffic.

Each incoming or outgoing on-line activity is recorded complete in the message store; each record contains the called subscriber's number, the answerback exchange, and transmitted or received text. Once the call has been cleared the message is printed out at maximum speed as soon as the printer is available; the stored message is deleted upon completion of printout. Stored messages can be edited readily by inserting and deleting text using the keyboard, and



Office communications: teleprinters, facsimile and teletex.

ITT3000 teleprinters. The modular version is to the left and the integrated version in the center.

can be transferred to diskette or punched tape.

ITT3535 Facsimile Terminal
Fast, accurate transmission of text, drawings, and photographs is guaranteed by the new ITT3535 facsimile terminal from SEL. High speed code reduces transmission time by 15%, which means that a DIN A4 letter can be transmitted in as little as 20 seconds. The ITT3535 can accept originals up to DIN A3, automatically reducing them to DIN A4. Half-tone raster scanning controlled by a microprocessor allows half-tone images to be sent with first-rate image quality.

The ITT3535 incorporates every facility to ensure ease of operation and high performance:

- liquid crystal display giving operator guidance
- abbreviated dialing with automatic repeat for up to 50 numbers
- log of all incoming and outgoing telecopies
- delayed automatic transmission with the transmission time being entered by the sender
- 300-page paper roll with automatic cutter
- automatic feed for up to 30 originals.

Suitable for operation at transmission speeds of 9600, 7200, 4800, and 2400 bit s^{-1}, the ITT3535 is an invaluable business tool for the immediate transfer of critical documents. A maximum resolution of 7.7 lines per millimeter ensures that fine detail is captured and provides crisp, readable copy.

ITT3150 Teletex Terminal
A new chapter in fast, easy and economic correspondence has been opened by

ITT3535 facsimile machine.

SEL's teletex terminal, the ITT 3150. Direct transmission of text is performed at electronic speed – an A4 page takes less than 10 seconds. First-quality typed letters are produced by a 30 character per second daisywheel printer for all Latin-based languages. Also, when required the ITT 3150 is able to communicate with all telex subscribers, automatically switching to the telex character set.

An ultra-slim moveable keyboard and easily-readable adjustable display featuring black characters on a light background allow text to be entered and corrected with ease. Word processing functions, including automatic insertion, deletion, and justification, allow text to be edited and make it possible to store standard messages. Incoming messages are stored automatically until required and outgoing messages can be stored for transmission at a predetermined time. Interchangeable storage for more than 200 pages of text supports the word processing functions.

ITT 3150 teletex terminal.

Telephone Subsets

Microelectronics has revolutionized the telephone service, and not least the subscriber's apparatus which offers reliability, compactness and a host of new features.

Introduction

For the many millions who use the telephone, the whole service is symbolized by the subset. Their view of the telephone service is determined by the appearance and feel of the subset, its ease of use, the clarity of sound, the facilities offered, and reliability. The niceties of switching and transmission are not even considered.

The subset represents not only a challenge in cost effective design for high quantity production, but an opportunity to take advantage of microelectronics to offer a wider range of facilities to the subscriber. Pushbutton dialing is becoming commonplace, making the entry of a number easy, quick and accurate. Numbers can be stored in memory to allow automatic dialing, and numbers and messages can be displayed. Data transfer facilities are being added to the basic telephone functions. Increasing digitization of the network will bring digital subscriber loops, with the advantages of digital transmission right into the subset. The present trend is to introduce digital operation into the office environment using a digital connection from the subset to the new generation of digital PABXs.

Many different subsets are to be seen on the ITT stand at Telecom 83, some static and several connected to the integrated network based on the ITT 1240 Digital Exchange. A diversity of styles reflects varying national tastes – from the futuristic Digitel 2000 to the friendly rounded Domino. Among the advanced features offered by some of the subsets are included credit card authorization, handsfree operation, abbreviated dialing, and a telephone for use by the deaf that displays written messages input through the keys. An attractive adjunct to the telephone is found in the STC wide-area radiopager, a very compact device that uses tone patterns to alert its wearer and identify call origin, urgency or specific action to be taken. A recent innovation is voice dialing, where a number can be called simply by speaking into the telephone, with spoken responses to guide the user. As with the text telephone, this has potential applications for handicapped subscribers.

The heart of the Pentaphone is a single, compact control unit suitable for wall mounting.

Pentaphone

Pentaphone, a versatile system produced by NSEM for the small commercial or domestic user, enables up to five standard subsets to be served by two exchange lines. No operator is needed, and any subset may be used to initiate any operation.

Microprocessor control gives an extensive range of facilities, which include:

- making calls to or receiving calls from the public telephone system
- transfer of external calls to another extension
- holding of an external call while making an internal enquiry to another extension
- three party conference by including a second extension in an external call
- personal or general paging by coded tones to all free extensions
- internal calls with call transfer and up to five party conference
- sequential, selectable ringing of extensions for both internal and external calls.

Simple, unobtrusive installation is ensured by a compact wall-mounted central unit requiring only two-wire cabling to the subsets; maximum cable length is 200 m.

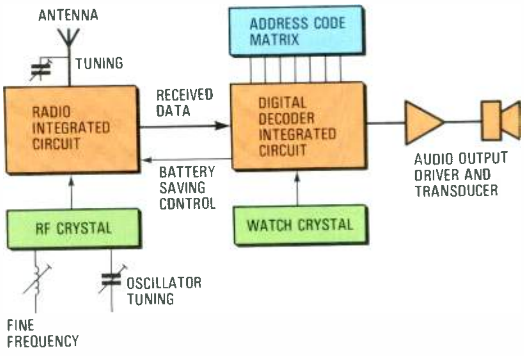
Wide-area Radiopager

The STC award-winning radiopager is one of the smallest and most attractive on the market, designed around two LSI devices. The slim, one piece tubular body is extremely rugged and conveniently carried in a pocket, on a belt, or clipped to a bag.

Use of the world standard POCSAG code (Post Office Code Standardisation Advisory Group) allows a competitive choice of compatible equipment by the paging system operator. The pager has four addresses, each distinguished by a different code pattern identifying the origin of a call, its urgency, or specific actions required of the user. To avoid inconvenient interruptions a memory mode can be selected which will store a call on each address.

The radio section, operating in the range 138 to 174 MHz, is contained on a single

Figure 1
Block diagram of STC's wide-area radiopager.



STC's wide-area radiopager.

patented chip, eliminating an IF strip and ceramic filters and allowing easy alignment (Figure 1). Efficient battery saving is achieved by allocating calls to specific time slots; the radio is switched off for a large proportion of the time, even on heavily loaded systems, giving a typical battery life of three months.

Text Telephone

The ITT text telephone brings to those with hearing and speech difficulties the convenience that subscribers using traditional telephones take for granted.

The text telephone is equipped with a typewriter keyboard and liquid crystal display that allow textual messages to be transmitted and received. Communication can be between two text telephones, or between a text telephone and a DTMF pushbutton subset, in which case a deaf person can be sent a text message encoded through the ten keys of the pushbutton instrument, and speak the reply in the ordinary way.

Correct connection of the text telephone, dial tone, answer by the called party,

1. BTM's Uniphone comes in a range of eight colors and offers pushbutton VF, pushbutton quickstep, and rotary dialing. The subset can be wall mounted if desired. This durable and well proven electronic telephone is designed for constant use with comfort in a wide range of environments.

2. BTM's range of universal public coin telephones is based on a proven capability dating from the first operational units delivered to the Belgian Telephone Administration in 1939. Versions are available for local and international calls. Features include rugged design, pushbutton or rotary dialing, multislot coin mechanisms, and credit display.

3. The Orangephone indoor paystation is a convenient and cost effective alternative to the public telephone in supervised private locations, offering additional services to users and ensuring direct payment of calls. This mobile, lightweight unit manufactured by BTM is easy to install and operate, and connects directly to a standard subscriber line.

4. Features of SEL's Comfort pushbutton telephone include autodial for ten numbers, last number repetition, direct calling, loudspeaking operation, and adjustable tone caller.

5. The Consul from SEL is available with pushbutton or rotary dialing. The case is styled for easy carrying, with adjustable left or right handed handset cord exit. The volume of the tone caller is adjustable. A lock is built in to prevent dialing of unauthorized calls.

6. The Jumbo subset was specially designed for applications in hospitals and for use by the aged. This distinctive telephone manufactured by SEL is also useful for users who are required to make frequent telephone calls. Large recessed pushbuttons are mounted in a sloped housing for easy operation.

7. SEL's Vital telephone is especially useful for the handicapped, offering many facilities: large pushbuttons with adjustable operating force, autodialing for ten numbers, three to six environment pushbuttons for the control of mains powered equipment, handsfree facility, call signal lamp, and a handset with magnetic field generator for the control of hearing aids.

8. Intermat 2 incorporates a comprehensive display showing call progress and status, duration, and charges. This advanced microprocessor controlled telephone system from SEL is suitable for use as a main or secondary PABX system with a maximum capacity of six exchange lines and 12 stations. Features include abbreviated dialing, handsfree operation, and conferencing.

9. The Elektron is a fully electronic telephone designed and developed by STC, providing excellent speech quality together with high transmission stability. Its low profile styling is suitable for home and office and allows optional wall mounting. Technical features include decadic or MF signaling, dynamic transducers, tone caller, and snap-action keys.

10. Representing the latest telephone technology, STC's Executel is an intelligent display telephone designed to operate as a powerful personal management tool. Executel incorporates a diary; personal directory of names, telephone numbers and addresses; a notepad; calculator; and a clock. It can also act as a data or electronic mail terminal by bringing to the executive's desk the resources of both private and national viewdata systems. An optional secretarial extension unit is also available.

11. The Margherita multifeature set produced by FACE provides automatic answering, abbreviated dialing for 30 numbers, automatic repetition of last dialed number, call monitoring, key operated toll barring, volume control, and liquid crystal display.

12. Privacy Phone from FACE is an advanced microprocessor controlled subset with automatic answering and recording. Recorded messages can be accessed by a remote retrieval facility using coded voice commands. Operation of the machine is assisted by processor dialogue in simplified alphanumeric language. Self diagnostics are performed continuously, with automatic disconnection in the event of failure.

13. MIKE (multiwire Italian key system, electronic) has a maximum capacity of four exchange lines accessible by 12 extensions. The equipment consists of a compact wall-mounting central unit employing plug-in modules, and a subset with decadic pushbutton dialing, repeat of last dialed number, and direct station selection. Main features of this FACE manufactured equipment include: visual and audible indication of incoming calls, call diversion, ringer exclusion, conference, secrecy, night service, holding and automatic transfer of exchange calls, automatic connection of selected extensions to exchange lines in the event of power failure, and the facility for standby power supply changeover.

14. FACE's versatile and popular Domino comes with rotary dial or pushbutton versions with decadic or multifrequency dialing. The case is styled in a range of single and two tone colors. Optional features include repeat last call and abbreviated dialling.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ITT's multinational image is reflected in the wide range of telephones and key systems shown here. Although the styling varies considerably, reflecting national taste in design, all employ the latest technology to give high performance and reliability combined with ease of use. Together they offer the user a full range of advanced features, including DTMF dialing, abbreviated dialing, displays, and handsfree operation.


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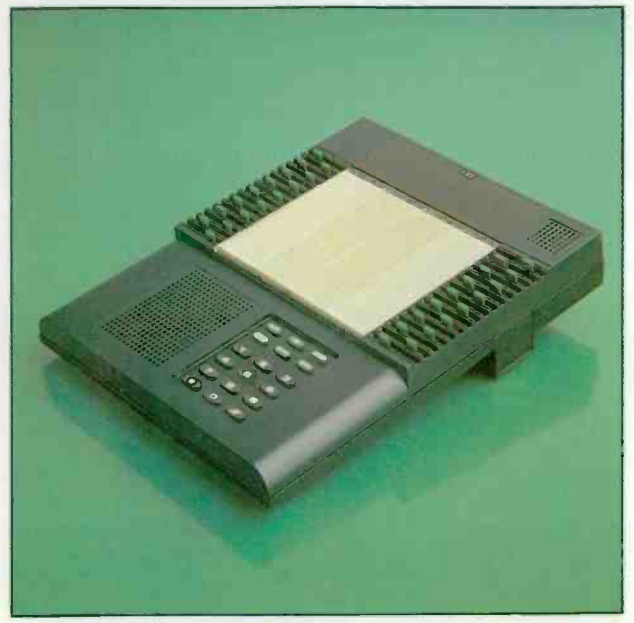
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15. **FACE's Gondolino memory phone 14 is able to store the subscriber's most used numbers and dial them automatically simply by pressing a single button; it can also automatically redial the last number called. A liquid crystal display shows dialed or stored numbers, time, and duration of call.**

16. **Modern, simple lines combined with a novel range of two tone colors suit the Barion to any decor in home or office. The set is produced by FACE and is available with rotary or pushbutton decadic dialing and memory for redial of last number.**

17. **Convenient and comfortable in use, the one-piece Arrivaphone incorporates a pushbutton dial with memory for automatic redial of last number. It is available from FACE in a range of two-tone colors.**

18. **Suitable for desk or wall mounting without modification, the Unitel subset from FACE is offered with rotary or pushbutton dialing (decadic or MF) with last number repetition. The ringer can be electromechanical or electronic, and the speech network can be passive or electronic.**

19. **FACE's compact Gondola is available in desk and wall mounting versions with rotary or pushbutton decadic dialing. A floating finger stop facilitates dialing with the small rotary dial. Six colors are available, plus leather covered models.**

20. **The Selectaphon IV repertory dialer from FACE features storage of up to 64 telephone numbers of 20 digits, call monitoring, automatic last number redial, toll barring by electronic key, storage of telephone numbers during conversation (agenda), and tone detection for automatic restart after a pause. A display shows dialed and stored numbers, time, and the duration of the call.**

21. **Dataphone from SEK is a low cost alternative to on-line terminals for purposes such as exchange rate enquiries and ordering of goods. Simultaneous conversation and data exchange is possible. Features include a built in 20 character per line alphanumeric printer operating at 2 lines per second, 16 DTMF pushbuttons, 7 special function keys, loudspeaker, and variable ringer.**

22. **SEK's Digitel 2000 answerphone/recorder combines an extensive range of normal telephone features, including a 10 number memory and loudspeaker, with an answering unit and tape recorder. The answering unit uses an endless tape cassette with playing times between 15 and 120 seconds. Recorded messages on the standard tape minicassette can be played back remotely from any DTMF pushbutton telephone by dialing a personal access code.**

23. **Storage of up to 30 telephone numbers, a 16 digit LED display, and handsfree operation are featured in this version of the Digitel 2000 manufactured by SEK. The handsfree facility employs speech controlled transmission and allows conversations to be conducted several meters from the telephone set.**

24. **The standard version of the Digitel 2000 was the first to be mass produced for the Jutland Telephone Company by SEK. It features a keyboard with 16 DTMF pushbuttons, 2 special function keys, fully electronic transmission circuit, and register recall. Among several other features are a volume control in the handset, loudspeaker, and adjustable tone ringer.**

25. **The standard range of Malaga telephones produced by SESA offers rotary dialing, or pushbutton dialing with either quickstep or multifrequency operation. Transmission and reception levels are regulated automatically. Recall of last number dialed is provided with quickstep operation.**

26. **The SESA Teide has electronic transmission with regulation of transmission and reception levels. High sound quality is ensured by using electrodynamic capsules in the handset. Pushbutton dialing is standard, and offers either quickstep or multifrequency operation. The set is available in desk and wall mounting models.**

27. **SESA's subscriber paystation is intended for indoor use in environments such as offices and restaurants. Three sizes of coin are accepted; unused coins are returned and used coins metered by a special exchange-installed unit, which enables new tariffs to be established by the Administration. The station is microprocessor controlled and features a liquid crystal display for credit and status indication.**

28. **The Ronda family of subsets is fully designed and developed by SESA. In addition to the basic subset, offering pushbutton DTMF or decadic versions, the family will include a microprocessor controlled secretarial subset, repertory dialer with liquid crystal display, multifeature subset, and key system using digital technology.**

29. **SESA's pushbutton version of the Gondola provides quickstep or multifrequency dialing, and a 22 digit memory capacity for recall of last number dialed. Transmission and reception levels are automatically regulated.**

NSEM's text telephone brings the convenience of two-way communication to those with hearing and speech difficulties.

engaged tone, and an incoming call are all indicated on the display. Incoming messages and keyed-in messages are buffered and scrolled onto the display. A built-in memory is able to store prepared text messages and record received text messages. Stored messages can be scanned and edited.

The text telephone, designed and manufactured by NSEM, is a self-contained portable unit and is approved for use with any normal telephone connection.

Tele-Check

STC's Tele-Check is a dual purpose unit which functions as a normal telephone and a credit authorization terminal. It provides a fast, accurate and secure method of checking and accepting credit transactions on up to ten different credit or bank check cards.

To operate the terminal the card is passed through the reader and the amount entered on the keyboard. Upon operation of the *proceed* key the terminal automatically identifies the database from the discrete

Tele-Check, STC's combined telephone and credit authorization terminal.

number, dials the host computer or authorization center, and sends the authorization request. The response is almost immediate and is clearly shown on the 32-character display. Should the response be a request to telephone the center, the number is dialed automatically and the call is routed to the handset. A comprehensive series of plain language prompts on the display leads the operator through all the required sequences. A fully self-diagnostic program can check all functions of the terminal and the communication channel back to the host computer. Program loading can be performed locally or remotely; all memory is non-volatile.

The telephone's features include a ten number repertory dialing store and automatic redialing of last number called.

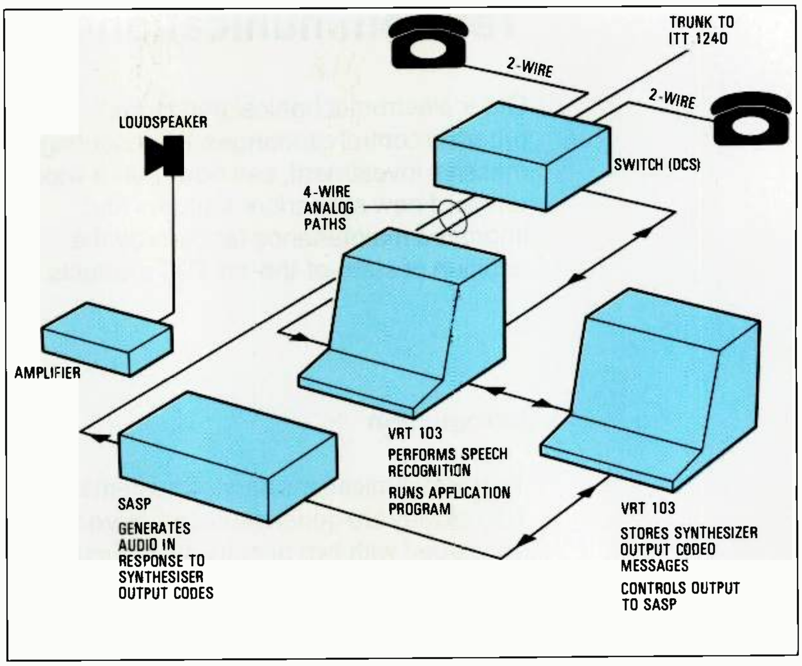


Figure 2
Voice dialing demonstration hardware configuration.

Voice Dialing Demonstration

Voice dialing, where calls can be established and facilities obtained directly through verbal commands, is technically feasible and offers completely handsfree operation combined with a high degree of user friendliness. The voice dialing demonstration (Figure 2) simulates a small office environment in which the PABX is equipped with speech recognition and synthesis facilities. Calls can be made, both within the simulated office and via the ITT 1240 Digital Exchange, by speaking the number, name, or location of the called subscriber set. The system also responds to verbal requests for assistance, communicating with the user in a natural sounding synthesized voice. Where the system is unsure of a command it will ask for confirmation. Features are included for directory look-up and call forwarding using interactive speech.

Telecommunications Service Systems

Older electromechanical and stored program control exchanges, representing a massive investment, can now offer a wide range of new subscriber features and improved maintenance facilities by the addition of state-of-the-art TSS products.

Introduction

Telecommunications service systems, or TSS as they are generally called, have been developed with two primary aims. First, to protect the massive investment in existing telephone exchange equipment by introducing features that are available on the most modern exchanges, thereby economically extending the useful operating life of exchanges, and enabling more rapid, widespread introduction of revenue earning features.

Second, telecommunications service systems provide for all generations of telecommunication equipment those new features and services that are implemented advantageously by peripheral equipment, rather than by the switching processors of modern analog and digital exchanges. The wide range of available products covers the areas of maintenance, traffic measurement and control, call charging, operator services, equipment modernization, administrative procedures, and new subscriber services. The following TSS products are on display on the ITT corporate stand at Telecom 83:

- Network quality tester that provides the fast and accurate service analysis that is necessary to maintain the telephone network in peak operating condition and satisfy subscriber demands for service quality.
- Local call simulator which is an ideal installation and maintenance test device for both PABXs and public local exchanges. Each unit can set up 16 simultaneous calls; for large exchanges several units can be operated in parallel.
- Call handler for advanced telephone services offering custom calling facilities to subscribers irrespective of the type of exchange to which they are connected. Facilities include call waiting, repeat,

STR's network quality tester central control facility is able to control up to 150 remote units to allow rapid and comprehensive assessment of the performance of the telephone network.

diversion and barring, three-party conference, and abbreviated dialing. All features are programmable from the subscriber's subset.

- Microprocessor-based call diverter that allows a subscriber to have calls to his number rerouted to other locations. The diverter is located at the exchange, so only one subscriber line is required.
- Automatic line test and administration system which detects and identifies marginal and hard faults on subscriber lines and in telephone subsets. In addition it provides a range of functions for the efficient management of a line plant repair center.
- Signaling converter that overcomes the problem of differing interexchange signaling systems in many telephone networks.
- Digital call simulator UCS-D for testing modern digital switching systems; this operates on the 2.048 Mbit s^{-1} and 1.544 Mbit s^{-1} digital trunks using all the usual signaling systems.

Network Quality Tester

The NQT (network quality tester) provides complete service analysis of the telephone network. The NQT consists of remote units located in local telephone exchanges and a control unit located in a main exchange or maintenance center. A typical network configuration is shown in Figure 1. Remote units, fully self-contained, have the task of setting up telephone calls to any exchange, testing them, and storing the results of the tests. The central unit, the heart of the system, transmits a test program to each remote unit according to the required maintenance schedule for the exchange. Remote units are called periodically to collect test results; all results are processed automatically and reports are generated ready for use.

The central unit is based on a minicomputer and has sufficient power to control up to 150 remote units; communication with the remote units is via a transmission circuit consisting of a subscriber interface and modem. In addition to the remote unit, a simplified end unit is available for use in small local exchanges and PABXs; this unit cooperates with the remote unit. It answers single calls and sets up acknowledgment calls to the associated remote unit. Two end units can be served by a remote unit.

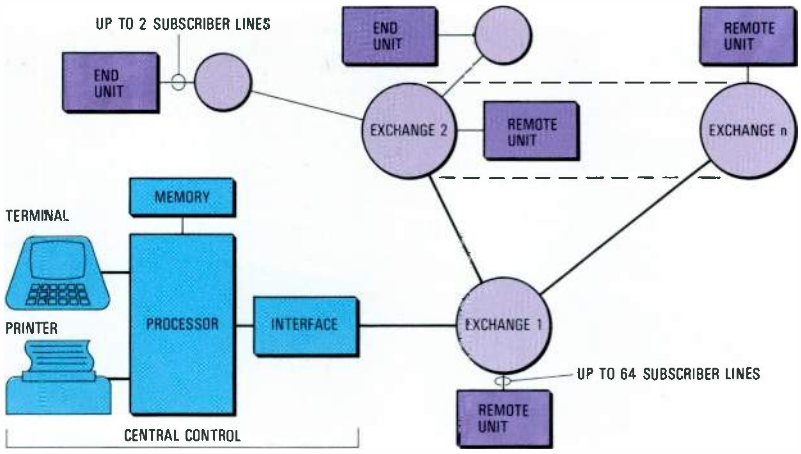


Figure 1
A typical network configuration for the network quality tester.

Summarized or detailed reports and statistics covering all maintenance activities can be delivered:

- network quality
- faults
- dial-tone delay
- dial-tone level
- ringing-tone level
- switching-through delay
- transmission level
- noise level
- metering.

A network quality tester remote unit.

The NQT is operated from a simple VDU terminal with an ASCII keyboard. Although remote units are normally controlled by the central unit, for local operation they can be accessed by exchange personnel. In this case man-machine communication takes place by means of the operating panel, or with the aid of a teleprinter or VDU terminal.

Local Call Simulator

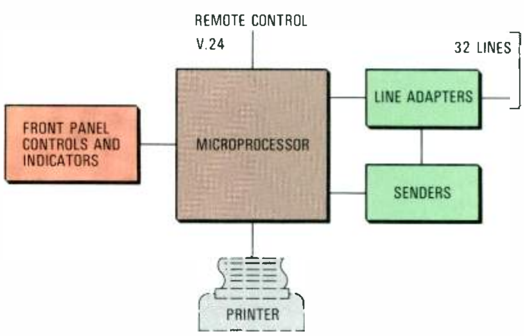
Able to set up 16 simultaneous calls, the local call simulator is an ideal test device for both public local exchanges and PABXs.

Front panel of the STR local call simulator.

The performance of exchange lines, control, concentration, and grade of service can be assessed quickly using one or a number of simulators. Using optional remote control, a group of simulators distributed between exchanges can be used to set up coordinated network traffic.

An extensive range of facilities includes pulse or DTMF signaling at selectable speeds, numbers of up to 16 digits, dial-tone test, tone recognition, selectable test

Figure 2
A simplified block diagram of the local call simulator.



sequences, synchronized or unsynchronized test calls, and self-testing. Provision is made for recording test results on an external printer.

Front panel controls and indicators allow selection of the number and category of each of 32 subscribers, test mode, timing parameters, and the data to be printed out. Tests are supervised automatically, with selectable automatic response to fault conditions.

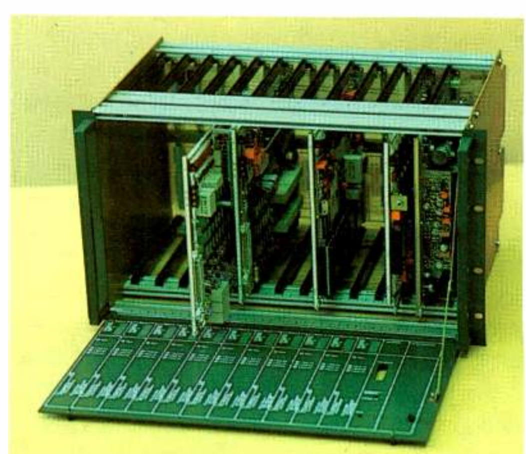
There are several special features. A buffer battery maintains all data in low power stores for up to 24 hours in the event of power failure. The line allocation of calls to multiple lines can be dore under program control. During systematic testing of subscriber lines the numbers for each group are automatically incremented by a preselected amount upon restart. The simulator can be started by an external signal, with a remote alarm signal in the event of a fault being detected. A self-check program makes it possible to verify quickly and at any time that the equipment is functioning correctly in all respects.

A simplified block diagram of the local call simulator is shown in Figure 2. The simulator is program controlled using an 8085 microprocessor with the program written in high level PL/M, stored in EPROM. After the simulator has been connected to subscriber lines in the local exchange to be tested, all the desired data (e.g. the numbers of the connected lines, individual line characteristics, system parameters, and testing mode) are entered via a keyboard on the front panel and testing can begin.

Call Handler for Advanced Telephone Services

CHATS (call handler for advanced telephone services) offers the following custom dialing facilities, normally available only from modern electronic exchanges, to subscribers connected to existing electromechanical exchanges:

- three-party conference
- call waiting
- call transfer
- barring on incoming calls, with or without spoken message
- barring of outgoing calls



Call handler for advanced telephone services.

Table 1 – CHATS configurations

CHATS facilities	Universal subscriber board	Simplified subscriber board	Diversion board	DTMF transceiver board	An-nouncing board
Call waiting	×		×		
Three-party conference	×		×	(x)	
Call diversion (immediate or on no reply)	×		×		Option
Barring incoming calls with spoken message	×		×		Option
Barring incoming calls without spoken message	×	×			
Barring outgoing calls	×	×			
Repeat last call	×	×		(x)	
Abbreviated dialing	×	×		(x)	
Hot line	×	×			
DTMF-pulse conversion				×	
Remote programming				×	Option

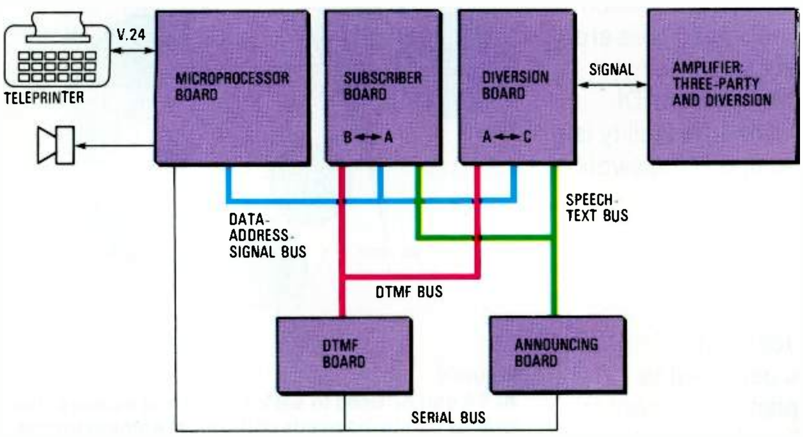


Figure 3
CHATS block diagram.

– repeat last call
– abbreviated dialing
– hot line
– DTMF dialing.

Facilities can be programmed from the subscriber's telephone set or even remotely from any other telephone.

CHATS is installed in the exchange and connected to the subscriber lines at the main distribution frame. Modular design using printed board assemblies mounted in a subrack allows flexible configuration of the required facilities. Each subrack is controlled by its own microprocessor. A generic block diagram is shown in Figure 3, with possible configurations shown in Table 1.

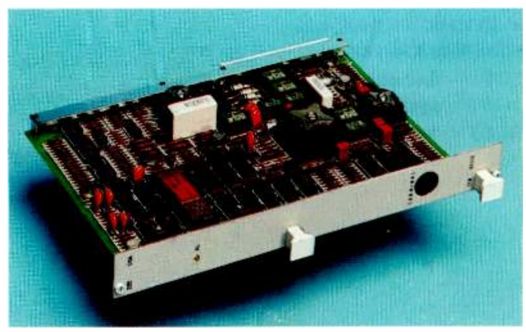
Call Diverter

A new call diverter (CADI) designed by NSEM ensures that subscribers with this facility can receive calls at locations other than their office, even when the caller does not know the subscriber's whereabouts. An advantage to the operating Administration is that the use of a call diverter prevents lines being blocked on unanswered calls.

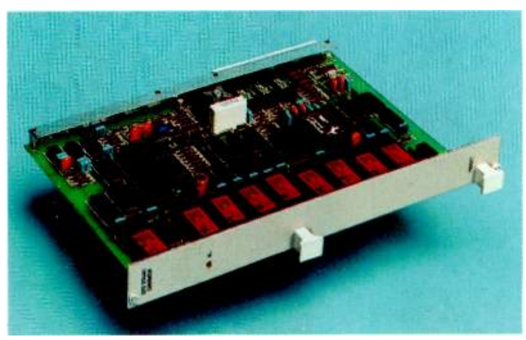
The diverter is installed in the exchange, thus simplifying maintenance and ensuring there are no line voltage, earthing, and power supply isolation problems. It also means that only one subscriber line is required per subscriber, so no additional attenuation is introduced.

The subscriber can activate the call diverter from his telephone subset or, optionally, from any other subset. Automatic call diversion is possible to a third party either by preprogramming the diverter or by remote reprogramming by the subscriber.

The microprocessor-controlled call diverter is mounted on a single printed board. Up to 12 units can be accommodated in a 19 inch subrack. Options available for joint use within small groups of CADI units include a speech generator, and a separate control unit for centralized system management and traffic data collection.



NSEM's microprocessor-based call diverter.



Speech generator for the call diverter.

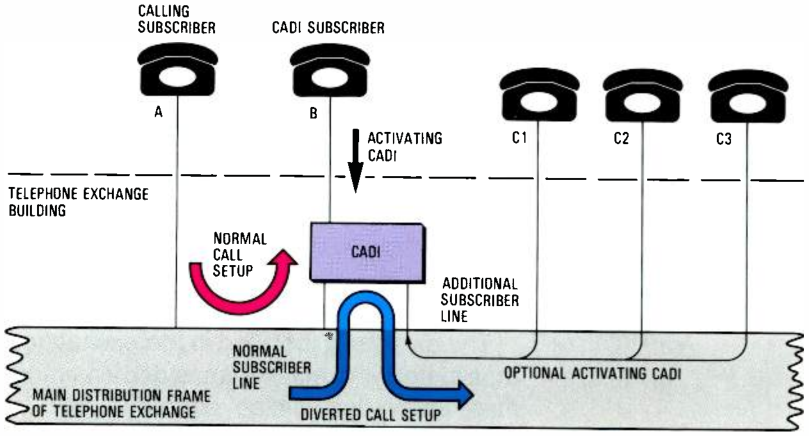


Figure 4
Schematic showing how the NSEM call diverter is connected.

Figure 4 shows how the call diverter operates. When a call from subscriber A to subscriber B is not answered within a predetermined time, the preactivated CADI unit automatically diverts the call to the telephone number programmed into the unit's memory (subscriber C). When call diversion is in progress, the calling subscriber may receive a spoken message from the optional central speech generator. Speech (or tone) messages are also available during local or remote programming, or activation of the CADI.

As a further option, a follow-me facility is available; access to this feature is password protected.

ALTA

ALTA, an automatic line test and administration system, is designed to provide an efficient line plant repair center. The system automatically detects and identifies marginal and hard faults on subscriber lines and in telephone subsets (Figure 5), generally before they result in a subscriber complaint. Testing is possible throughout a network, irrespective of distance. Other facilities include support for monitoring complaints, processing service requests, and monitoring line status. ALTA also administers and maintains a line record database.

The ALTA system consists of microprocessor-based modules linked by a high speed control bus and a voice bus. Complaint calls and service requests are distributed to a free operator by the call distribution function, thus minimizing waiting time and improving operator efficiency.

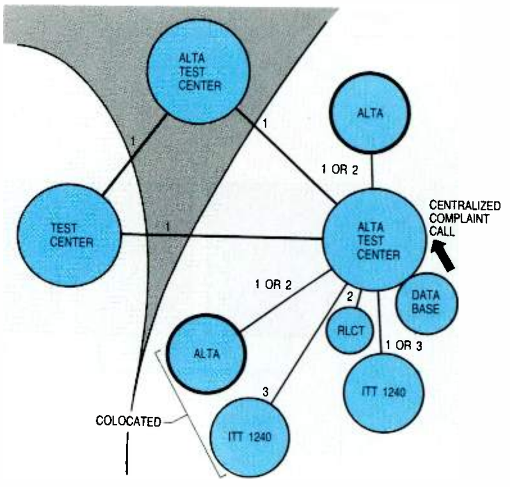
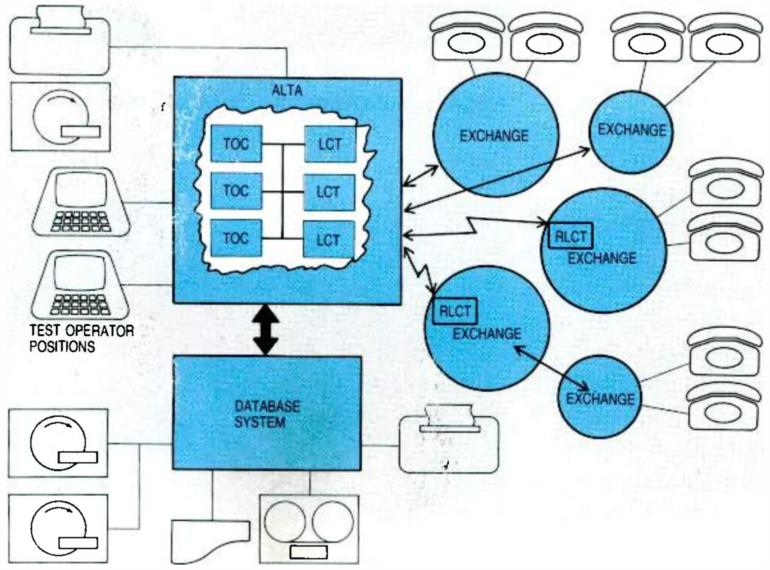


Figure 6
ALTA can be used to set up a line test network that exactly meets the needs of the local Administration.

Figure 5
Structure of Taisel's automatic line test and administration system.
LCT - line condition test unit
RLCT - remote line condition test unit.



The test operator position, which is equipped with a VDU, detachable keyboard, and voice adapter, is controlled by the TOC (test operator controller). Commands are input in menu mode to reduce training time and minimize operator problems. A database linked to the system speeds up the handling of complaints and service requests and reduces repair times by providing operators with immediate access to all relevant data. This database also records test results and provides statistics for efficient fault analysis and service management.

A distributed control architecture allows flexible expansion in line with an Administration's operational requirements. System modularity means that ALTA can be used in a wide range of applications from a test desk in an exchange up to a fully

Line plant repair and administration center based on Taisel's ALTA system.

automated test center. The hardware is supported by modular software which facilitates customer adaptation and system expansion.

Outgoing communication links enable all operators to communicate whith other ALTA centers or installations. ALTA can also act as a remote man-machine communication device for any digital exchange with built-in line testing facilities.

Figure 6 illustrates how ALTA allows an Administration great flexibility in setting up multiple test centers; the area, number of exchanges, and subscribers assigned to each center can be organized by the Administration for maximum efficiency.

Unilink Signaling Converter

Telephone networks in many countries include a mix of telephone exchanges of different generations from various manufacturers. Frequently, incompatible interexchange signaling systems make it impossible for them to communicate directly. Although new exchanges now use standard signaling systems, they are still unable to communicate with the plethora of existing exchanges without extensive and costly application engineering.

To overcome these problems, NSEM has developed a signaling converter that allows an exchange to work directly with exchanges that use other signaling systems. Thus the Unilink signaling converter offers an economic solution to the problem of incompatible interexchange signaling systems, and facilitates the introduction of new exchanges into the existing network. The latter feature will make it particularly useful during the evolution to an integrated digital network.

Figure 7 shows the structure of the microprocessor-based Unilink converter for digital exchanges. The signaling multiplexer, which handles the signaling for 30 channels, sends and receives line signaling in timeslot *16*. A universal asynchronous receiver-transmitter is

Printed board for the Unilink signaling converter.

Unilink signaling converter, manufactured by NSEM, which overcomes the problem of incompatible interexchange signaling systems.

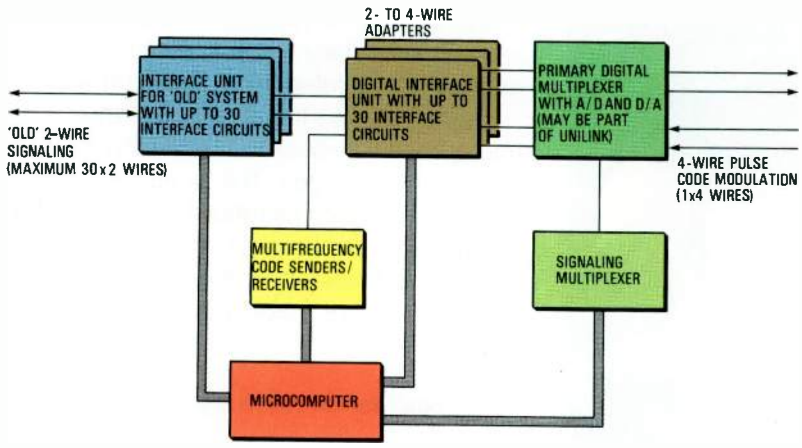


Figure 7
Structure of the Unilink digital signaling converter.

included for man-machine communication, and a direct memory access facility allows the input and output of data via the signaling multiplexer.

Seven basic program modules provide all the necessary function: monitor program, interrupt handler, standard line signaling program, system interface program, signaling multiplex program, register program, and man-machine communication program.

Normally when an exchange is replaced in an existing network, other exchanges may require costly modifications which could be used for only a short time before those exchanges are themselves replaced, or even modified again. In contrast, when a Unilink signaling converter becomes redundant, it can be reused elsewhere in the network. At most this requires reprogramming of the microcomputer and replacement of a few printed boards.

Universal Call Simulator for Digital Switching Systems

Digital switching systems using 2.048 Mbit s^{-1} and 1.544 Mbit s^{-1} trunks can be tested efficiently using the UCS-D call simulator. This test equipment is suitable for use with common channel signaling and any of the usual channel-associated signaling methods such as R1, R2, CCITT No 4, CCITT No 5, and DC loop.

The UCS-D consists of a control unit, up to four trunk units, a printer, and a VDU terminal (Figure 8). It is the ideal tool for the following range of tests:

- grade-of-service measurements
- functional operation tests
- traffic load measurements
- acceptance tests
- tolerance tests.

Fully equipped, the universal call simulator can set up and check 60 simultaneous transit calls. If necessary, several call simulators can be interconnected and run in parallel.

Commands and data are entered through the VDU terminal using man-machine dialog. Test results and detailed test data are output via the printer. These data are stored in the control unit on two floppy disks.

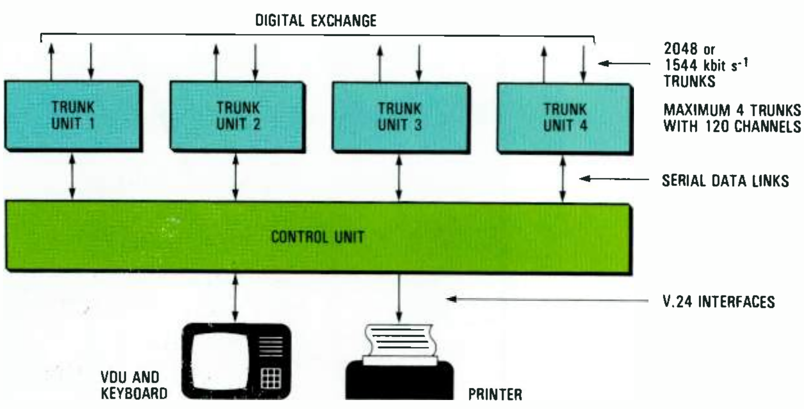
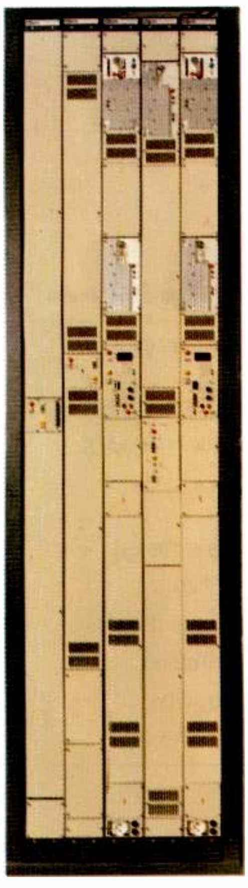


Figure 8
Basic configuration of the UCS-D call simulator for digital switching systems.

Transmission Systems

Transmission is undergoing a major revolution, the most important aspects of which relate to digitization of all parts of the network and the implementation of integrated networks to provide new subscriber services.



BTM digital transmission equipment, including 2, 8/34, and 140 Mbit s^{-1} muldex racks and a 140 Mbit s^{-1} coaxial line terminal rack.

Introduction

Today by far the greatest part of the world's telephone traffic is voice service using analog transmission. This state of affairs will remain substantially unchanged for a long time yet, mainly because of the existing very large investment in transmission and switching plant. A revolution is nevertheless taking place that embraces not only switching and transmission, but the nature of the services offered to subscribers. This change is being brought about largely as a result of the economy of digital transmission, particularly using optical fibers.

Transmission of digitally encoded voice offers high and constant quality regardless of distance and allows wider repeater spacings on conventional transmission media. Digital transmission also lends itself to the direct handling of a host of non-voice services and is a fundamental requirement for providing integrated voice and data services to every subscriber using a single public switched network.

Optical transmission through fibers of astounding transparency offers very wide repeater spacings using compact, lightweight, and rugged cable. The future points to monomode transmission with high bandwidth and the use of longer wavelengths for reduced attenuation. Optical transmission has developed into a viable and economic alternative to metallic cables for medium and long haul applications, and its potential in the subscriber area is increasingly exciting. The large bandwidth per unit cross section of fiber, many times greater than that for metallic cables, will be the key to delivering future broadband services to homes and offices.

Radio relay equipment, with its specific advantages in difficult terrain, is unchallenged by optical or metallic cables. Here the trend is towards digitization and the use of sophisticated modulation techniques to provide large capacity systems.

The ITT corporate stand shows only a representative selection of the many ITT transmission products covering the whole range of transmission requirements. Further products are found on the stands of other ITT system houses. The various ITT houses frequently cooperate in the development of equipment that is designed to meet specific common applications.

Coaxial Cable Systems

140 Mbit s^{-1} Coaxial Line Equipment

A prerequisite for an integrated services digital network is a compatible range of standardized transmission units that are able to operate throughout the network. The coaxial line transmission equipment from BTM fulfills all transmission requirements for the first four hierarchical levels recommended by CCITT.

The basic first order system allows time division transmission of 30 PCM speech or data channels on a 2.048 Mbit s^{-1} bitstream. Any signaling requirements of existing exchanges can be accommodated; signaling solutions are in accordance with CCITT Recommendation R.2, thus guaranteeing compatibility with new digital switching equipment.

The product range of higher order systems allows the transmission of up to 1920 channels:

- 2nd order, 8.448 Mbit s^{-1}, 120 channels
- 3rd order, 34.368 Mbit s^{-1}, 480 channels
- 4th order, 139.264 Mbit s^{-1}, 1920 channels.

Positive justification is used, allowing lower order plesiochronous bitstreams (tributaries) to be multiplexed onto a single bitstream. All higher order multiplexers operate in accordance with CCITT Recommendation G.703.

Line equipment includes terminal racks for adapting the PCM signal to the line and controlling and powering dependent repeaters, the repeaters themselves, and a remote supervision unit. The 140 Mbit s^{-1} line equipment is suitable for use with either 1.2/4.4 or 2.6/9.5 mm coaxial cable.

18 MHz Coaxial Line Equipment T05E

The T05E, a coaxial line equipment operating in the 18 MHz frequency band, meets all relevant requirements of CCITT for high performance circuits in coaxial cables, and allows the simultaneous transmission of 3600 two-way telephone channels. The equipment, developed by SESA in cooperation with SEL, can also be used for transmission of 1800 two-way telephone channels plus one television channel, or two television channels in each direction.

The attenuation of the coaxial pair used as a carrier is compensated by repeaters along the transmission path, at regular intervals of 2 km on 1.2/4.4 mm coaxial pairs, or 4.55 km on 2.6/9.5 mm coaxial pairs. Terminal repeaters are used at both ends of the transmission link, and each of them can supply remote power feeding for up to 32 dependent repeaters. Main repeaters along the path can also feed up to 32 dependent repeaters in either direction. Thus the spacing between power feeding stations is 118 km for small (1.2/4.4 mm) coaxial cables or 295 km for large (2.6/9.5 mm) coaxial cables.

The main repeater stations also incorporate branching or dropping facilities for the injection or extraction of telephone and/or television channels.

The transmit path is controlled by pilot frequencies; detection of an incorrect level in the pilot receiver gives an alarm indication signal.

Fault location in the transmission path is based on a supervision system in which each power-fed dependent repeater is equipped with two characteristic frequency generators, one for each direction. The failure of a line amplifier causes the interruption of its own characteristic frequency as well as the characteristic frequencies of the preceding dependent repeaters. To locate a failure in the power feeding circuit, a reversed polarity voltage is applied and then the loop resistance is measured. The main technical characteristics are shown in Table 1.

Low Capacity Transmission Systems

A new generation of 12-channel transmission systems has been developed by SESA. These systems are designed to meet the requirements of Administrations in rural areas by combining high reliability and small size.

Both systems, each of which meets all relevant CCITT recommendations, are:

- *SOJ*, a 12-channel open-wire line system which can cover up to 200 km repeater spacing on a suitable bearer circuit.
- *K*, a 12-channel pair cable system, which can cover up to 40 km repeater spacing on a suitable bearer circuit.

Both systems have been designed in the V-SEP* practice; various mechanical arrangements are possible, either for operation in telephone exchanges (vertical rack) or for community centers (wall box).

SESA 18 MHz coaxial line equipment.

Table 1 — Main technical characteristics of 18 MHz coaxial line equipment

Carrier frequency transmission band	312 to 17043 kHz
Transmission band with pilot frequencies and fault location	200 to 18480 kHz
Coaxial cable types	1.2/4.4 or 2.6/9.5
Nominal repeater spacings	2 or 4.55 km
Maximum distance between main (power feeding) repeater stations	118 or 295 km
Mean repeater section loss at +10 °C and 18480 kHz	45.7 dB
Line pilots	308 and 18480 kHz
Pilot level	−10 dBm0
Total noise according CCITT	280 pW0p
Power feeding current	110 mA ± 2%

* A trademark of ITT System

Optical Fiber Systems

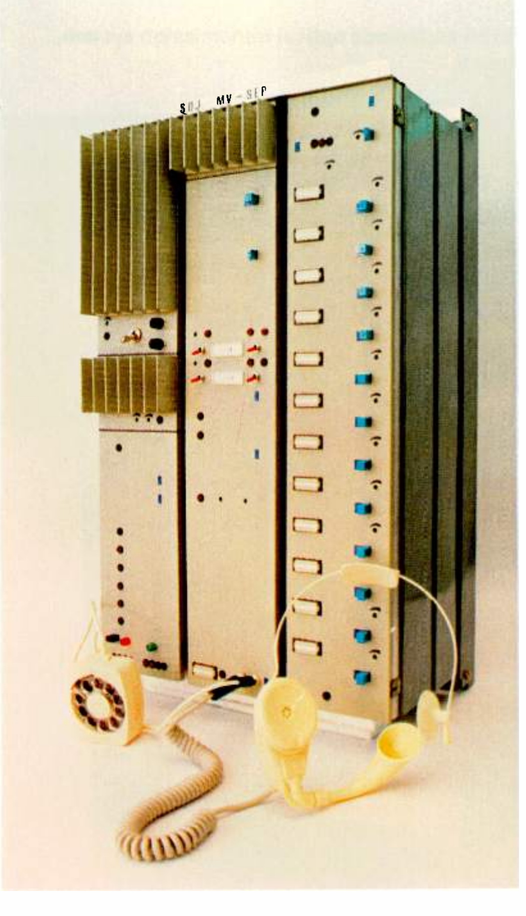
Optical Line Equipment for 34 Mbit s^{-1}
SEL's 34 Mbit s^{-1} optical transmission system provides interfaces meeting CCITT Recommendation G.703 and is thus an alternative to conventional line equipment for symmetrical or coaxial metallic conductors. There are two types of system available, working at different wavelengths:

- 0.85 μm system allowing a repeater spacing of at least 8 km, if a graded index fiber is used with a 3.5 dB km^{-1} attenuation
- 1.3 μm system which allows for a longer repeater spacing of about 20 km with the lower attenuation of graded index fibers at that wavelength.

In addition to conversion of electrical digital signals to optical digital signals, the line equipment includes supervision, fault signaling, and power feeding for repeaters on long transmission links.

A multimode optical transmission system operating at 140 Mbit s^{-1} has also been developed by SEL, with a wide range of applications.

SESA 12-channel line transmission system.

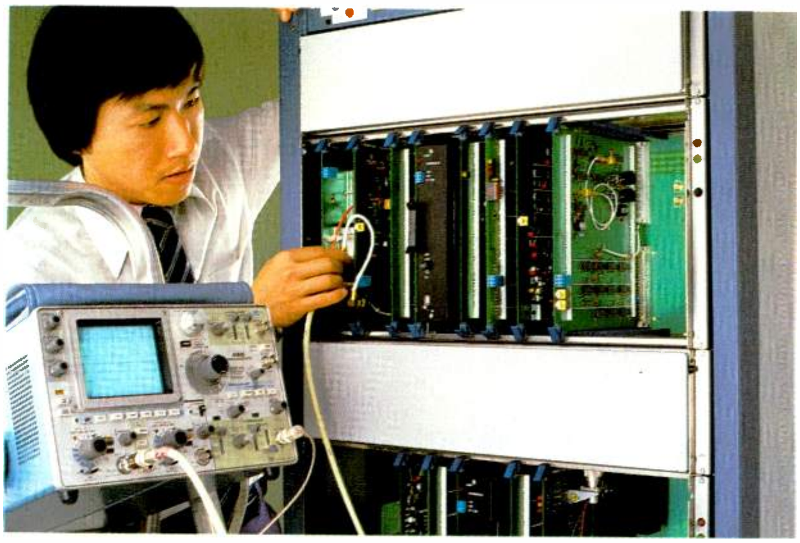


SEL 34 Mbit s^{-1} optical line equipment.

140 Mbit s^{-1} Single Mode Optical Transmission System
The STC 140 Mbit s^{-1} single mode optical line system can be used either for long distance circuits extending to hundreds of kilometers or as an unrepeatered local link of up to 30 km. It provides a transmission link for digitally encoded information in the CCITT 140 Mbit s^{-1} format. Each system can carry up to 1920 simultaneous telephone circuits or a mixture of telephony, broadcast quality television channels, sound programme channels, and data traffic. A standard code mark inversion interface at 139264 kbit s^{-1} is provided in accordance with CCITT Recommendation G.703.

The system operates over single mode fibers with a reference surface diameter of 125 μm and a nominal core diameter of 8 μm. One such fiber is used for each direction of transmission. A semiconductor injection laser operating at a wavelength of 1.3 μm generates the optical signals. In many applications the very large spacing that is possible between equipment eliminates the need for power feeding arrangements for intermediate repeaters. In addition, as the supervisory system operates over the traffic carrying fiber, copper conductors are not needed in the cable. This significantly reduces system complexity, installation, and maintenance.

The complete system can be monitored from either terminal by means of a



STC 140 Mbit s^{-1} single mode optical transmission system.

supervisory system which operates on a telemetry path provided on the traffic carrying fibers. Interrogation and response signals are transmitted by frequency shift keying a low frequency carrier added to the traffic signals modulating the laser. Alarm indications and test points are provided on the terminal and intermediate repeaters to facilitate maintenance and rapid restoration of service in the event of a fault.

The complete two-way line terminal equipment is housed in a single shelf of the STC Mark 8 equipment practice.

TRACOF System

TRACOF* is a 0.85 μm, 1 Mbit s^{-1} multimode optical fiber transmission system designed by SESA, for applications in the telecommand, telemeasuring and telecontrol area. It consists of a number of terminals linked by optical cables in various network configurations (point-to-point, star, ring, etc), over distances ranging from hundreds of meters to several kilometers.

A Tracof terminal includes an optical transmitting and/or receiving unit; each unit connects a maximum of 15 line units and provides for synchronization and control of those units. A line unit can handle digital or analog electrical signals, optical signals, voice communication, or computer interfaces. Each unit can accept up to 15 simultaneous signals and incorporate them in a 32-bit frame (15 information bits, plus 17 bits for synchronization). The frames are multiplexed, thus enabling a maximum of 225 different signals to be transmitted over a single fiber in either direction. By introducing a second level of multiplexing, the capacity of the system can exceed 3000 signals.

Because of the inherent characteristics of optical fiber, Tracof is especially suited for telemeasurement and control applications in harsh environments, where electrical and magnetic interference is high or the atmosphere contains explosive or corrosive agents. Examples are electrical power installations, railway signaling and communication systems, industrial control, mines, and so on.

Tracof offers extended modularity both in terminals themselves and in network configuration, which offers a wide range of transmission capacities. The use of optical fiber for the transmission path makes the system highly immune to interference, radiation, and weather extremes, and protects staff and equipment from lightning and electrical damage. High differences in ground potentials at either end of the line are also tolerated without any disturbance to transmitted data. Long spans can be covered without a repeater. All these features, combined with a dramatic reduction in equipment weight and size, result in low maintenance requirements, cost effectiveness, and high performance, compared with conventional systems.

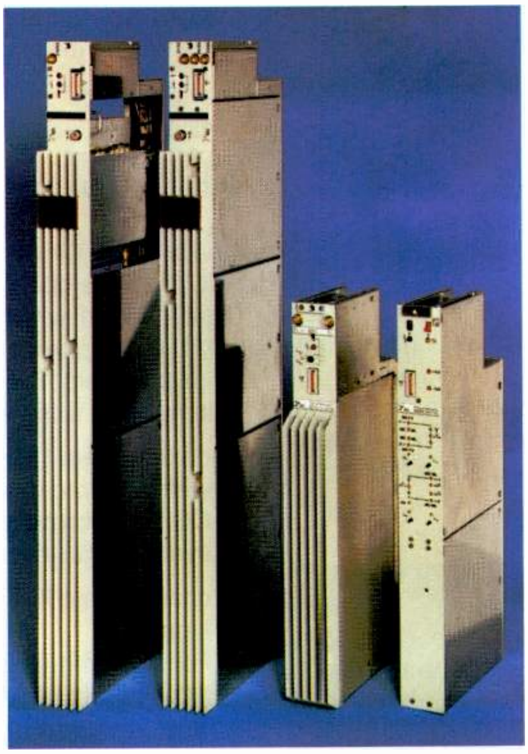
SESA multimode optical transmission system, Tracof.

* A trademark of ITT System

Radio Systems

Digital Radio Relay Systems for 34 Mbit s⁻¹
Two digital radio relay systems have been developed by SEL for transmission at 34 Mbit s^{-1} in the 2 GHz and 13 GHz frequency bands in accordance with CCIR Recommendations 283-3, 382-2 and 497-1. Both equipments can operate over the entire frequency range of the band concerned, using offset QPSK modulation. A radio system signal frame is used for the transmission of digital service channels and supervisory signals. Protection switching equipment allows equipment standby operation and diversity operation with bit-synchronous switching.

The slimline 7R6 equipment practice is used for both systems. The transmitter, receiver, switching subrack of the protection switching equipment, and control unit each constitute a separate mechanical assembly; all units can be easily removed from the rack for maintenance purposes.



Subracks for SEL 1.9 GHz system. From left to right these are the transmitter, receiver, switching subrack, and control subrack.

Digital Radio Relay System for 2, 8 and 34 Mbit s⁻¹
A digital radio relay system manufactured by BTM operates in the 1700 to 2300 MHz band. The equipment is available in three versions, offering 30, 120, and 480 PCM channels capacity at 2, 8, and 34 Mbit s^{-1}, respectively. The solid state transmitter operates at four alternative RF power levels

BTM digital radio relay system.

between 0.5 and 6 W; the RF level is continuously adjustable to optimize system performance. Complete duplication is possible, using either frequency diversity or hot standby; both versions are also available for space diversity.

Other features of this advanced technology equipment include:

- phase locked direct modulation transmitter with low power consumption
- low receive noise figure, using an RF amplifier and image rejection mixer
- service channel giving six supervisory channels
- modular construction using either V-SEP or 19 inch rack equipment practice.

Low Capacity Radio Relay Systems
A range of three radio relay systems developed by FACE operate in the 450, 900, and 1500 MHz bands. Each system can transmit up to 132 FDM telephone channels; the system can also carry 2 Mbit s^{-1} PCM signals. These FM radio links have been designed for low capacity networks and are readily integrated into the latest communication systems. Typical applications include spurs to low population centers, railway support networks, pipelines, mining operations, and electricity networks. The solid state design, using advanced technology, features:

- performance in compliance with CCIR and CCITT recommendations
- high reliability and long service life
- AC/DC operation
- engineering order wire

FACE low capacity radio relay system – switching and services subrack.

- facilities for the injection of up to eight telegraph channels
- plug-in units for easy extension of traffic capacity
- easy installation using V-SEP equipment practice
- built-in metering for routine measurements
- alarms for transmitter and receiver changeover and pilot failure.

SRT HF90 high frequency radio communication equipment.

HF Radio System

SRT supplies a range of reliable units for the configuration of high frequency radio communication facilities, especially suitable for use by embassies and ministries. The transmitter covers the frequency range of 1.5 to 30 MHz and is available with outputs of 100, 400, or 1000 W. A synthesized solid state receiver covers the frequency range of 10 kHz to 30 MHz. It offers single knob continuous or digital tuning in steps of 1, 10, 100, or 1000 Hz and an internal memory for up to 109 preprogrammed channels. The transmitter driver is available as an individual unit or combined with the essential receiver functions in a version suitable for embassy applications.

A remote control unit allows optimum siting of the transmitter and receiver, such as outside a crowded city. All functions can be controlled over normal telephone lines or via a radio link.

A traffic control unit includes a variety of optional plug-in modules for the connection of ancillary equipment, such as microphone, headset, keyer, and teleprinter. The range of equipment, which allows complete installations to be built up, also includes VFT units for the reduction of telephone lines needed for remote control, a selection of aerials including an active aerial for reception, and automatic request and forward error correction equipment to improve the reliability of telex transmission.

Multiplexers

Universal 30-Channel PCM-Multiplexer

SEL has developed a multiplexer DSMX64K/2F which combines 30 channels of 64 kbit/s and/or pulse code modulated voice channels. There are two types of channel card with two channels per card:

- channel card DSK for 64 kbit/s signals with a codirectional interface according to CCITT Recommendation G.703 for synchronous networks
- channel card FEK for 4 wire audio signals.
  For signaling, two E & M channels are provided (R2 digital/R2 analog).

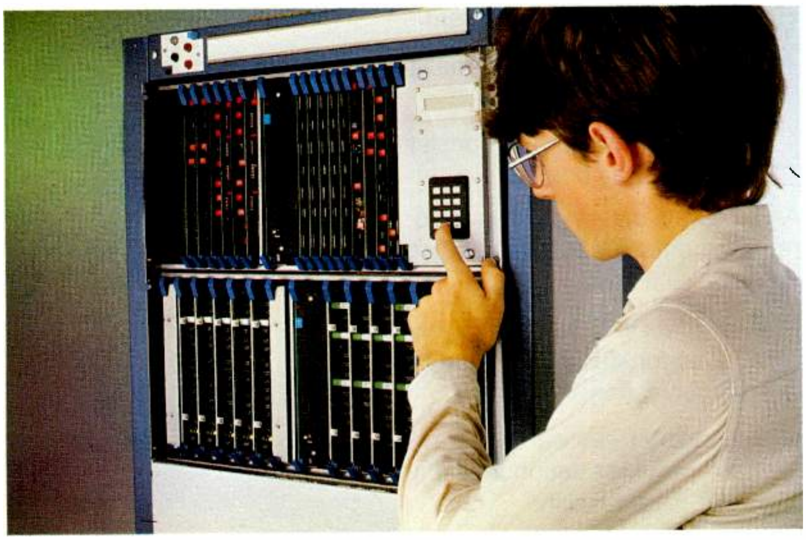
These channel cards can be combined without restriction.

The subrack is constructed in 7R equipment practice.

Higher Order Digital Multiplexers

SEL's range of higher order multiplexers provides for multiplexing at the 2/8 Mbit s^{-1}, 8/34 Mbit s^{-1}, and 34/140 Mbit s^{-1} levels. Multiplexing is performed at each level using bit interleaving of the four lower rate signals. Clock alignment is maintained using positive pulse stuffing as recommended by CCITT. All units employ the 7R equipment practice, using 120 mm wide vertical racks. All units can be interconnected to form a multiplexing hierarchy as part of a line or radio relay transmission system.

60-Channel Transmultiplexer
STC's 60-channel transmultiplexer features bidirectional conversion between FDM and PCM signal formats and provides an interface compatible with analog and digital equipment to CCITT Recommendations G.233 and G.703. The compact, low power consumption design is housed in a new equipment construction. Performance of the transmultiplexer meets or exceeds CCITT Recommendations G.792/3.



STC 60-channel transmultiplexer.

The transmultiplexer enables Administrations to introduce and interwork digital switching and transmission equipment in their existing analog networks, including international circuits on submarine and satellite links. A further use is to establish temporary alternative routing between digital and analog systems. One FDM standard supergroup of 60 channels in the band 312 to 552 kHz is converted by the transmultiplexer into two PCM streams of 2048 kbit s^{-1}, each carrying 30 channels. Conversion takes place at the group, supergroup, or 2048 kbit s^{-1} levels to eliminate demultiplexing at the audio level, thereby considerably reducing degradation associated with back-to-back channeling.

Pilot regulation and generation can be included in the FDM connection. All carrier supplies can be generated internally, and may be synchronized to an external frequency standard.

Modems

ITT 2089 High Speed Data Modem
Data modem 2089, manufactured by SRT, complies with CCITT Recommendation V.29 for synchronous transmission at 9600, 7200, and 4800 bit s^{-1} on 4-wire leased telephone lines. An optional 4-channel multiplexer module can be provided which features pseudocarrier operation on an individual channel basis. Using this module, all combinations of 2400, 4800, 7200, and 9600 bit s^{-1} can be carried.

A single or double dial back-up facility enables a circuit to be re-established over the public switched network in the event of loss or degradation of the leased line. Both 2-wire and 4-wire restoration are possible, providing for half and full duplex operation, respectively. Modem 2089 also offers manual dialing back-up control or fully automatic control for unattended sites.

A powerful automatic adaptive equalizer allows data transmission at high speeds over unconditioned lines, thus lowering PTT leasing costs and usually improving line availability.

In addition to the standard CCITT recommended training time of 253 ms, modem 2089 has a strappable option providing for a training time of only 27 ms – a prerequisite for efficient data transmission over polled multipoint networks. Changing the data rate in the dedicated master modem in a network automatically adapts the remote slave modem(s) to the chosen data rate. Instructions from the communication controller via the data signaling rate selector cause both modems to change to a new speed without manual intervention.

Modem 2089 may be operated over a wide range of network configurations, including: leased lines (2- or 4-wire, half or full duplex, point-to-point or multidrop operation), using the switched public network as a back-up facility; switched lines (2-wire, half duplex); switched lines (2×2-wire, full duplex).

Comprehensive diagnostic facilities are built in; tests may be controlled manually from the front panel, or from the associated data terminal equipment via the data interface.

Left-to-right: SRT high speed data modem, SRT minimodem, and SESA data modem.

Modem Series 1180/1181/1182
A comprehensive range of FSK "minimodems" from SRT is suitable for use with various terminals, including personal computers, videotex, and point-of-sale terminals. All provide asynchronous transmission using the CCITT V.24 interface. Features include:

- alternative power sources
- single printed board design for desktop unit or rack mounting
- digital loopback
- automatic answering (1180/1181 and 1182B only)
- autocall option (1182A and 1182VT only)
- interspeed option (1182 only).

The characteristics of the various models, offering full duplex operation over the public switched network, are as follows:

300 bit s^{-1} according to CCITT V.21

- modem 1180A – call originate only
- modem 1180B – call answer only
- modem 1181 – call originate/answer.

75/1200 bit s^{-1} according to CCITT V.23

- modem 1182A
- modem 1182VT – for videotex with autocall/tone detector.

Modem 1182T offers full duplex operation at 1800 bit s^{-1} over a 4-wire leased line using frequencies according to Bell 202.

Data Transmission Modems for 300 to 4800 bit s^{-1}
SESA has developed a new series of data modems in which a primary aim has been to meet Administration requirements using a versatile design in standard sizes. The versions, all of which meet CCITT recommendations, are as follows:

- modem for 300 bit s^{-1}, consisting of a single plug-in printed board
- modem for 600/1200 bit s^{-1}, consisting of a single plug-in printed board
- modem for 2400 bit s^{-1}, consisting of two plug-in printed boards
- modem for 4800 bit s^{-1}, consisting of two plug-in printed boards.

As an option catering for specific requirements, the following equipment units are available:

- Voice/data unit, which allows the line to be used for either voice or data communication.
- Secondary (backward) channel unit, which provides secondary channel use as a separate facility.
- Automatic answering control unit and switched line control unit. Both units enable operation in a switched telephone network.

For local installation of the equipment, separate boxes are available, each holding three or six units. Large subracks and racks can be provided for installation in exchanges.

Rural Applications

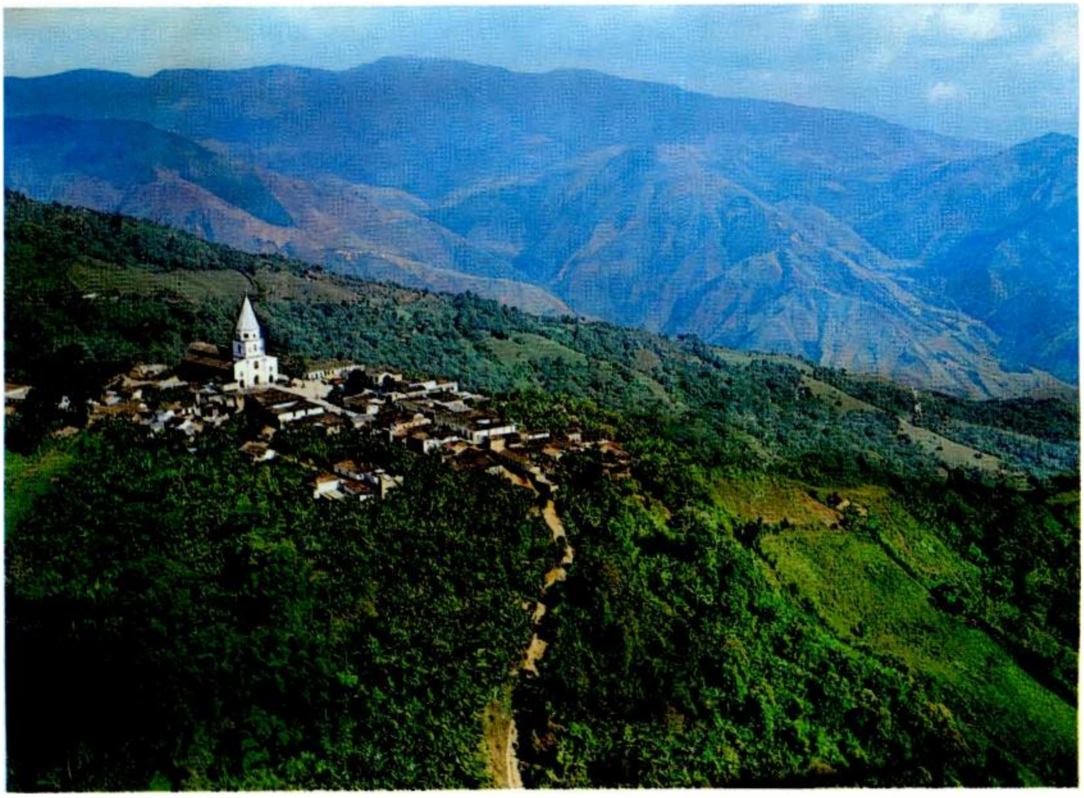
New technology is providing cost effective solutions for expansion of the telephone network to remote subscribers in rural areas.

Introduction

In an ideal world for the telecommunications engineer, population density would be either evenly distributed or concentrated solely into city areas. In practice neither is the case, and many subscribers are found in isolated locations, either individually or in small groups. This situation creates a conflict between the need to provide telephone service to everyone, and an unjustifiable installation cost compared with revenue received from these rural areas. The only solution is to install equipment that minimizes the cost per subscriber and operates reliably for long periods without maintenance. Reliability is of particular concern because alternative routing will not normally be available. Also, if full telephone network facilities can be offered, the installation cost can be further offset by increased revenues. Another point to consider is that the telephone is the tool of civilization and its presence in rural situations is, in the long term, likely to promote expansion of local commerce and industry and thereby further accelerate the economic development of that area. With such a possibility, modular equipment design that allows ready incremental expansion of service is a distinct advantage.

Digital technology and its partner, microelectronics, have made a tremendous impact on service for the remote subscriber. Examples are found in the RSU (remote subscriber unit) of the ITT 1240, which brings the latest in modern digital exchange features to the most remote subscribers at an economic cost. The ITT 1240 RSU is briefly described in this section, as well as the 10-channel PCM concentrator from STK, which provides a cost effective alternative in many localities to the more usual 30-channel configurations.

One result of the increased worldwide demand for high quality voice communication is that many public telephone Administrations have the



Isolated communities and areas of low population density pose special problems in the provision of telephone service. Many ITT companies have long experience in the assessment of rural needs and the development of optimum equipment solutions.

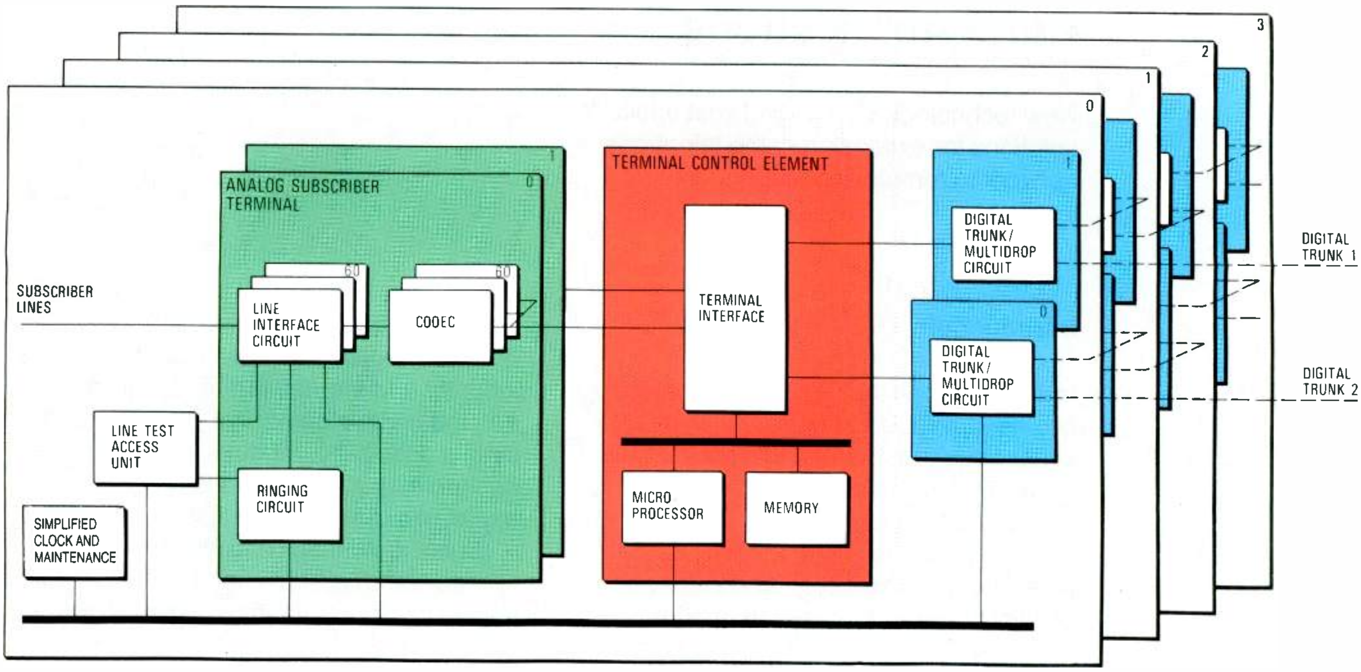


Figure 1
ITT 1240 remote subscriber unit.

responsibility for providing full telephone facilities in areas with low population density – sometimes within a short timespan. Often the climate or terrain that characterizes these areas makes the installation of conventional landlines difficult and therefore even more costly. A solution that gives the benefits of comparatively low initial costs and complete flexibility of location and number of subscribers is found in the rural radio telephone system produced by BTM. This system, which offers full compatibility with all types of automatic telephone networks utilizing cable distribution, is briefly outlined in this section.

The ITT presentation at Telecom 83 demonstrates equipment that brings positive benefits to Administration and remote subscriber alike, in the continuing growth of the world's telephone networks. All of the equipment uses the latest component technology to ensure low power consumption, troublefree operation, high performance, compactness, and ruggedness.

ITT 1240 Remote Subscriber Unit

The ITT 1240 RSU is a concentrator for connecting remote subscribers to a parent local ITT 1240 Digital Exchange. It provides subscribers with the same features and facilities as a local subscriber directly connected to an independent ITT 1240. Also the call handling, maintenance, and administration features are the same as for other modules of the parent exchange, of which the RSU is a fully dependent and integrated part.

The RSU is connected to the parent exchange via either one or two CCITT/CEPT standard 32-channel, 2 Mbit s^{-1} PCM links. Remote subscribers have full access to any channel of the PCM links. Furthermore, calling and called subscriber lines that are connected to the same RSU can be connected within the RSU.

Figure 1 shows the basic structure of the RSU which consists of an analog subscriber module (terminal plus control element) and a combined digital trunk/multidrop circuit, providing connections for 128 subscribers. In its full configuration, four such groups can be colocated, providing service for 480 subscribers. Alternatively, up to eight RSU groups can be distributed at different locations, sharing either one or two PCM links in a multidrop configuration (Figure 2). In this case some of the RSUs will be only partially equipped.

The maximum number of subscribers that can be served depends on the traffic and the desired grade of service: all 30

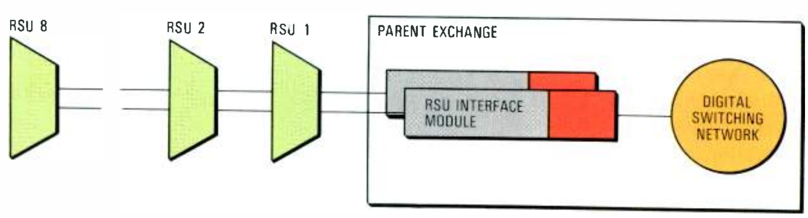


Figure 2
Duplex multidrop configuration for connecting up to eight RSUs (maximum of 480 subscriber lines) to a parent ITT 1240 Digital Exchange.

channels of the link are fully available to any subscriber in any RSU module. Typically, 480 subscribers with low traffic (0.08 erlang, say) per line can be concentrated for rural applications.

In the event of a transmission line fault all RSU modules remain in service by using the intact PCM link.

Each PCM link is controlled by the parent ITT 1240 exchange through a special RSU interface module, as shown in Figure 2.

The design of the RSU takes advantage of the modular structure of the ITT 1240 hardware and programs. Most of the hardware and program building blocks used in the RSU are also used for ITT 1240 local exchanges. The hardware in fact consists of the standard analog subscriber and digital trunk modules, the latter differing only in the program loaded. Additional circuitry provides the multidrop function, and a special transmission interface board is included which contains PCM line repeaters, link reconfiguration circuits (bypass and loopback), repeater feeding circuits that enable repeaters to be fed remotely from the parent exchange, and maintenance access and supervision circuits.

Optionally, where the RSU is located at a considerable distance from the parent exchange, a remote repeater feeding power supply can be equipped in the RSU to increase the number of repeaters on the line.

A simplified clock based on a local crystal oscillator is used for the RSU. This internal clock can be phase locked to either of the incoming 2 $\mathrm{Mbit\,s^{-1}}$ PCM bitstreams from the parent exchange.

Programs for the RSU are similar to those for ITT 1240 terminal modules with the addition of a data communication facility for interprocessor message communication. This facility is provided by a simplified version of common channel signaling on channel *16* of the PCM link, between the control elements in the RSU and the RSU interface module.

Using this message transmission capability, call handling finite message machines can be relocated between RSU and RSU interface module. Telephonic device handlers for the line interface circuit and ringing circuit are remoted to the RSU while the signaling logic is located within the RSU interface module. The interfaces between RSU and parent exchange are transparent, providing the exchange with the same electrical and logical characteristics as a colocated subscriber module.

RSUs have their own local database and maintenance functions. To facilitate local maintenance a hand-held terminal can be plugged into the RSU, enabling maintenance personnel at the RSU to request tests for a newly replaced pluggable item or repaired subscriber line and obtain a result before leaving the locality.

10-Channel Pulse Code Modulation System

The standard European 30-channel PCM system gives a substantial pair gain on existing cables, using a regenerator spacing equal to the loading coil spacing. However, for sparsely populated areas where only a few circuits are required, and the large distances involved make repeater spacing a dominant factor, the 30-channel system may not be the most suitable. By using a lower bit rate, repeater spacing can be increased at the expense of the total number of channels. Based on this principle, a 10-channel unit has been developed by STK in cooperation with the Norwegian Telephone Administration. Operating at 704 $\mathrm{kbit\,s^{-1}}$, as against 2048 $\mathrm{kbit\,s^{-1}}$ for the 30-channel system, a repeater spacing corresponding to three or four loading coil

Fully equipped multiplex shelf for trunk applications; this is constructed in the VSEP-N equipment practice.

Line terminating assembly for STK's 10-channel PCM system.

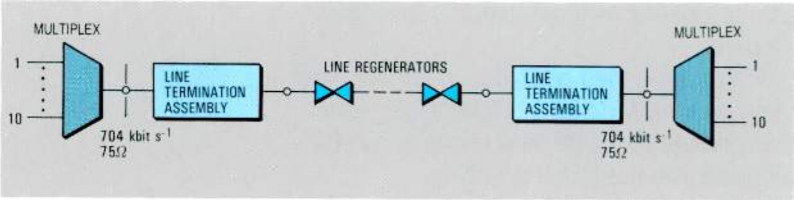


Figure 3
Schematic of the 10-channel PCM system devloped by STK.

sections can be achieved on small cables, giving the 10-channel system a significant economic advantage on long routes.

The complete system, as shown in Figure 3, consists of multiplexers and line transmission equipment. The multiplexer can accommodate either 10 voice channels with E & M signaling or 9 voice channels with one 64 kbit s^{-1} data channel. Optional units

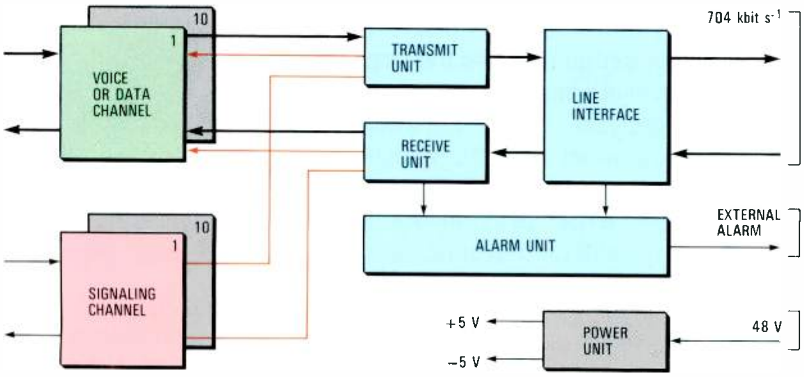
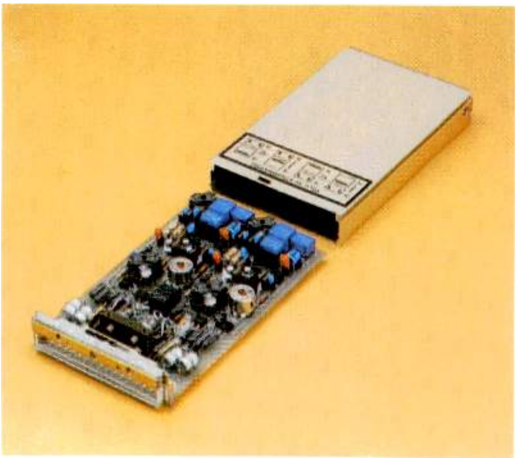


Figure 4
Schematic of STK's 10-channel multiplex equipment.

for access to spare bits in timeslot *0* and for common channel signaling can also be installed. A block diagram of the multiplex equipment is shown in Figure 4.

The digital output from each channel encoder consists of 8-bit bursts at the 2048 kbit s^{-1} rate, which are combined to form a continuous 704 kbit s^{-1} signal by the transmit unit. The receive unit performs frame and multiframe alignment, reconstructs the 8-bit bursts at 2048 kbit s^{-1}, and generates the required receive clocks. The use of 2048 kbit s^{-1} as an intermediate rate in the multiplexing process gives full channel-unit compatibility between multiplexers for 10 and 30 channels.



Line regenerator.

Rural Radio Telephone System

It is well established that for low population density areas where the subscriber to exchange distance exceeds a few kilometers, a radio telephone system requires substantially lower capital investment when compared with the cost of main feeder and distribution cable methods. This relationship is shown in Figure 5. At distances of up to approximately 60 km the cost of rural radio systems is completely independent of distance between exchange and subscriber.

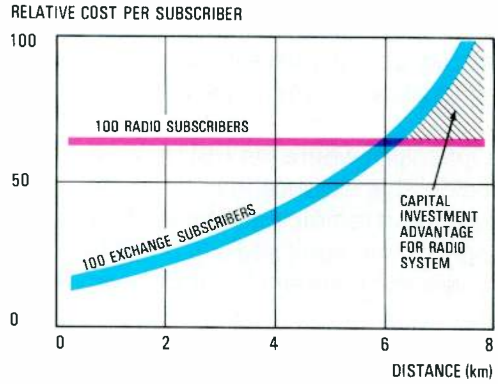
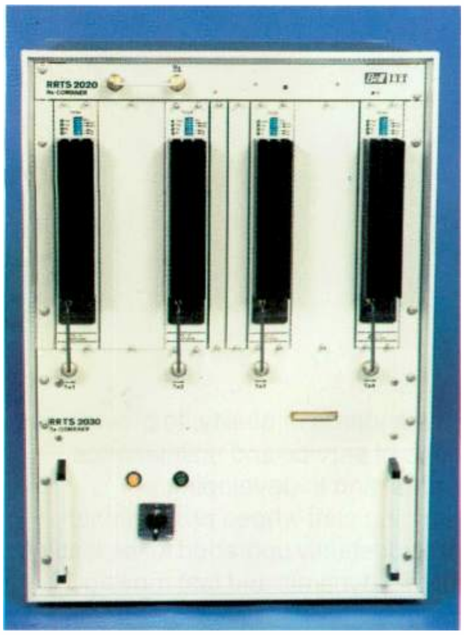


Figure 5 Relative costs of rural exchange and radio installations.

The system from BTM consists of a central base unit installed at the existing automatic exchange and a rural subscriber unit and telephone subset for each subscriber. The central base equipment contains transceiver, interface and logic circuitry for up to 256 subscribers per unit. The equipment acts as an autonomous concentrator/deconcentrator at the main distribution frame level, thus allowing existing exchange signaling to be used. A modular composition of up to 16 radio channels in groups of 4 or 8 channels allows expansion in line with demand.

System operation is based on a multiple channel random access principle that gives several benefits:

– efficient spectrum conservation



Rural radio exchange central base unit (left) and rural radio subscriber unit (right).

- minimum number of RF carriers
- simple interfacing with existing exchanges
- no standby channel needed
- each subscriber has access to every free RF channel.

Compelled digital signaling offsets the effects of propagation fading and thus ensures reliable subscriber selection.

The rural subscriber unit is a transceiver with a synthesizer under microprocessor control giving selection of 64 RF duplex channels. Low power consumption is achieved by use of LSI techniques and CMOS devices. The unit is fully self contained and can be provided in standard or waterproof versions.

The central base radio equipment, if necessary, can be located remotely from the exchange for optimum antenna positioning; connection between two sets of equipment is made by any conventional 4-wire telephone circuit.

Programming in ITT

Increasingly, the whole spectrum of telecommunication products from digital exchanges to subscribers' subsets will depend on the quality of programming in order to achieve high performance and cost effective design.

Introduction

Programming is one of the key technologies on which ITT, like other high technology companies, depends for its future success. The advent of digital technology in telecommunication has placed programming squarely in the critical path leading to modern, stored program controlled switching systems such as ITT's System 12. Manufacturers of telecommunication equipment are finding that programming accounts for more than half the development cost of a new switching system, and that a large toll exchange will routinely require in excess of a million program source statements.

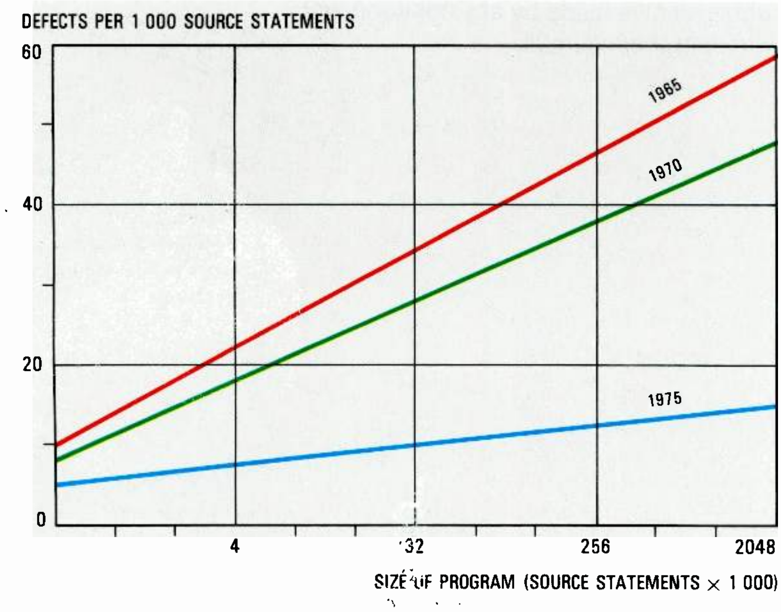


Figure 1
Programming defect performance, 1965 to 1975, showing numbers of defects during program lifetimes.

Thus success in programming has become essential to success in the telecommunication industry. However, success in programming means much more than developing programs capable of driving a switching system. It means a continuing commitment to maintaining the highest standards of quality, to providing new kinds of service and maintenance techniques, and to developing a programming staff whose professional skills are constantly upgraded to the leading edge of this dynamic and fast moving technology.

Diversity of ITT Programming Applications

ITT currently employs more than 8000 programmers at more than 100 locations worldwide. Although the corporation concentrated on the telecommunication area during its early years, it has become a much more diverse organization with activities in all areas of computer technology. For example, Hartford Insurance has one of the largest and most innovative data centers in the United States. Qume and Courier have worldwide reputations in the fields of terminals, printers, and computer peripherals. The ITT 3030 and 3710 microcomputers are well known in Europe, while in the US the Howard Sams Company is one of the leading publishers of computer-related books and manuals.

Of ITT's 8000 programmers, about half work on real-time and telecommunication programming, and the remainder on applications and support programming. Hartford Insurance operates the largest single programming facility, with more than 1000 programmers at its Hartford, Connecticut, data center. Other major ITT programming locations include Bell Telephone Manufacturing Company in Antwerp; Standard Elektrik Lorenz in Stuttgart and Berlin; ITT Defense Communications Division in Nutley, New Jersey; and ITT North Electric in Raleigh, North Carolina, and Delaware, Ohio. ITT programming activities worldwide are coordinated at the ITT Programming Technology Center in Stratford, Connecticut.

Programming Quality and Reliability

Stored program controlled digital exchanges have reliability requirements that are among the most stringent of any technical discipline. ITT plays a leading part in programming quality and reliability techniques, having conducted studies in every aspect of the field, from sophisticated mathematical predictors through local quality circles that involve individual programmers in personal techniques for achieving quality and reliability.

Defect prevention and removal are rapidly maturing sciences. As recently as the 1970s it was not uncommon for a large programming system to contain 50 "bugs" – defects that had not been prevented – per thousand source statements (see Figure 1); because the efficiency of defect removal procedures was unlikely to exceed 85%, an unacceptably high number of defects remained when the system went into operation.

The new generation of defect prevention techniques, including design reviews, code inspections and proofs of correctness, as well as formal testing, have reduced the number of faults to less than 5, while new defect removal techniques are 99% effective. This represents more than an order of magnitude improvement in defect rates as perceived by users. Zero-defect programs appear to be technically achievable within a few years.

Programming Service and Maintenance

ITT is dedicated to providing the highest levels of service in support of its programming products in the telecommunication industry. This commitment takes on a new meaning in the context of SPC switching systems, since the basic functions reside in programs rather than in electromechanical devices. New kinds of service tools and remote fault identification and repair facilities are needed to achieve high speed servicing, coupled with new methods for updating programs without affecting system operation.

It is highly probable that by the end of the century every telephone subset will contain a microcomputer, so there will be more microcomputers than subscribers. This will introduce new requirements for maintenance, which ITT is now exploring. In programming, maintenance has historically lagged behind development; however, emerging concepts of remote fault identification and replaceable modules may soon turn a programming trouble area into a leading edge asset.

Programming Productivity

The impact of SPC technology on telecommunication has made programming, rather than electronics or electromechanical design, the critical factor in developing a new exchange or enhancing an existing one. However, conventional programming practices today seldom exceed the range of 2000 to 4000 source statements per programmer year.

ITT is investigating new programming techniques, including program generators, reusable modules, and automated translation of design into code, for application in the development of large and complex real-time and telecommunication systems. These new techniques are starting to introduce order-of-magnitude productivity gains for the kinds of programs that lend themselves to these approaches. Figure 2 shows the overall expense elements of large programming projects.

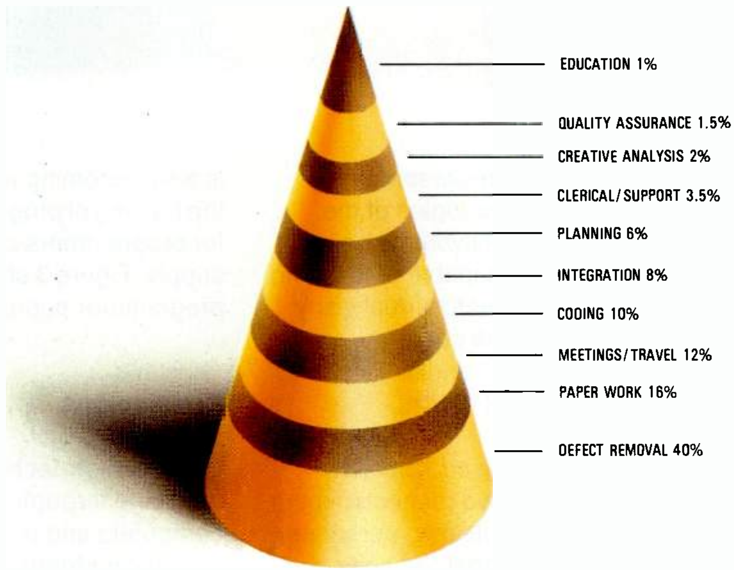


Figure 2
Expense elements in large programming systems.

Programming in Education

The coupling of computers with optical memories is leading to a major revolution in teaching methodology. Visual images on video discs controlled by programs that can

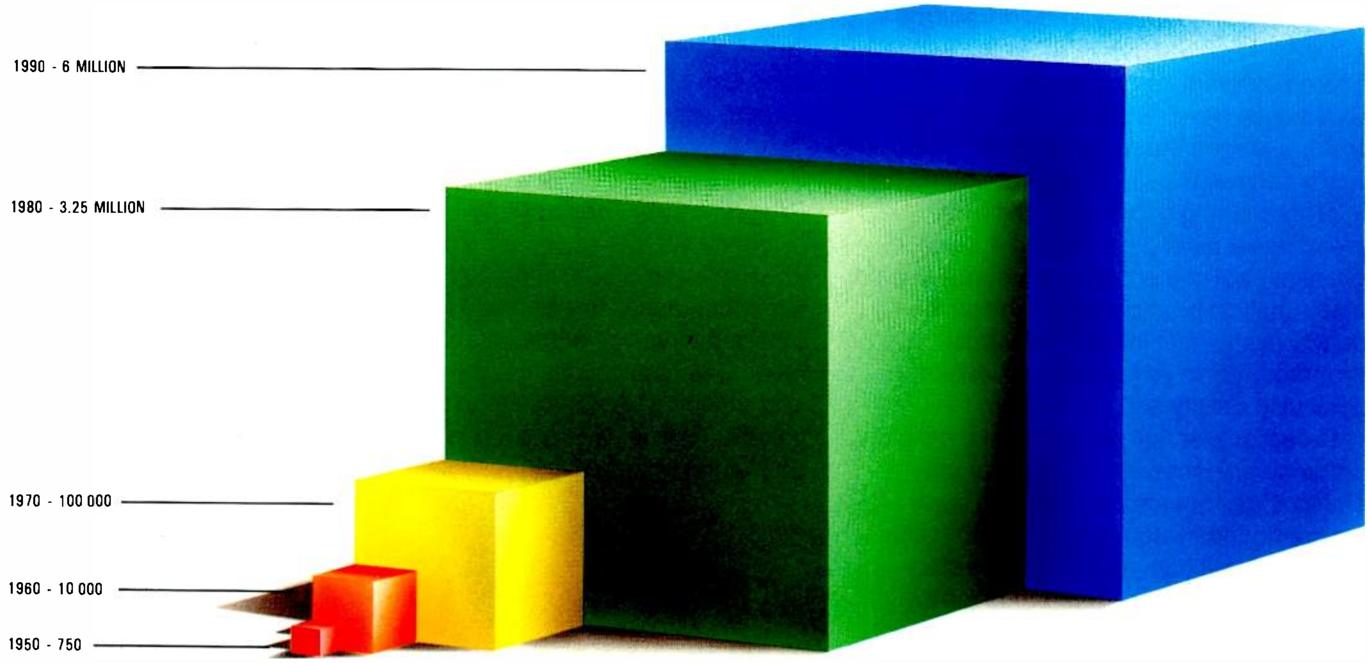


Figure 3
World programmer population.

interact with the student represent one of the most significant technologies of the 20th century. Educational systems being developed today will be capable of teaching virtually any subject matter to virtually any kind of student, and will be equally applicable in schoolrooms and in commercial and industrial training environments.

ITT is one of the leading educational companies in the US in two respects: in the education and training of its own personnel and, through ITT Educational Services, the Bobbs-Merrill Publishing Company, and the Howard Sams publishing company, in the production of textbooks and tutorial materials. The corporation is taking an active part in the education revolution by developing a computer-controlled video disc teaching system. Computer education is also becoming increasingly significant in the training of programmers, since the need for programmers continues to outpace the supply. Figure 3 shows the worldwide programmer population from 1950 to 1990.

Conclusions

In every high-technology field from medicine through telecommunication, computers and programming are introducing fundamental changes in the way activities are carried out, the way products are developed and maintained, and even in the kinds of functions that products perform. ITT has committed itself to excellence in programming, as it has always been committed to excellence in telecommunication.

ITT Communications and Information Services Inc

Telecommunication in ITT is not restricted to producing advanced electronic equipment. A number of companies, grouped under the banner of ITT COINS, offer comprehensive communication services ranging from a convenient news and information service to assistance with directory preparation.

Introduction

ITT Communications and Information Services Inc, or ITT Coins, was formed to unify ITT's service capabilities in communication, software development, and information management. The company is a one-stop worldwide resource center to help business and government organizations make better use of resources to solve their productivity problems. The display at Telecom 83 describes these capabilities and demonstrates them in action. In fact, one ITT Coins unit is offering an electronic message service on the stand that will enable delegates, media representatives, and other VIPs to keep in touch with their home and office during the exhibition.

Five major demonstrations are planned: a news and information center, an electronic message exchange, electronic yellow pages, directory operations services, and three data communication functions – database access, compatibility, and facsimile.

ITT Worldcom telex switching control center.

News Center

Four new ITT Digivision* television sets display up to the minute news and information throughout the week of Telecom 83. Located at the entrance to the ITT stand, the sets display news from United Press International and other agencies, as well as news about current developments from the ITT Corporation.

These television sets are driven by four asynchronous 1200 bit s^{-1} terminals which retrieve and display information from ITT Dialcom. Three of the terminals have a video output connection to the television sets via coaxial cable, while the fourth connection is via an ITT FACE microwave transmission system, illustrating the diverse capabilities of ITT equipment and services.

Electronic Message Center

The message center at Telecom 83 uses the services of ITT Dialcom's electronic mail system, based in Silver Spring, Maryland, USA. The connection to Geneva is via a 4-wire M1020 line. At each end of the line is a V.29 modem with an aggregate transmission rate of 9600 bit s^{-1}. On the digital side of the modem is a multiplexer with an aggregate data rate of 9600 bit s^{-1} and up to eight 1200 bit s^{-1} asynchronous ports (V.24/V.28 interface). The ports are connected to ITT Qume's QVT102 terminals which access the ITT Dialcom database at Silver Spring, Maryland (Figure 1).

The message center allows individuals to register their names and receive messages from their home, office, or other visitors. The center enables anyone to send a message, properly formatted and addressed,

* A trademark of ITT System

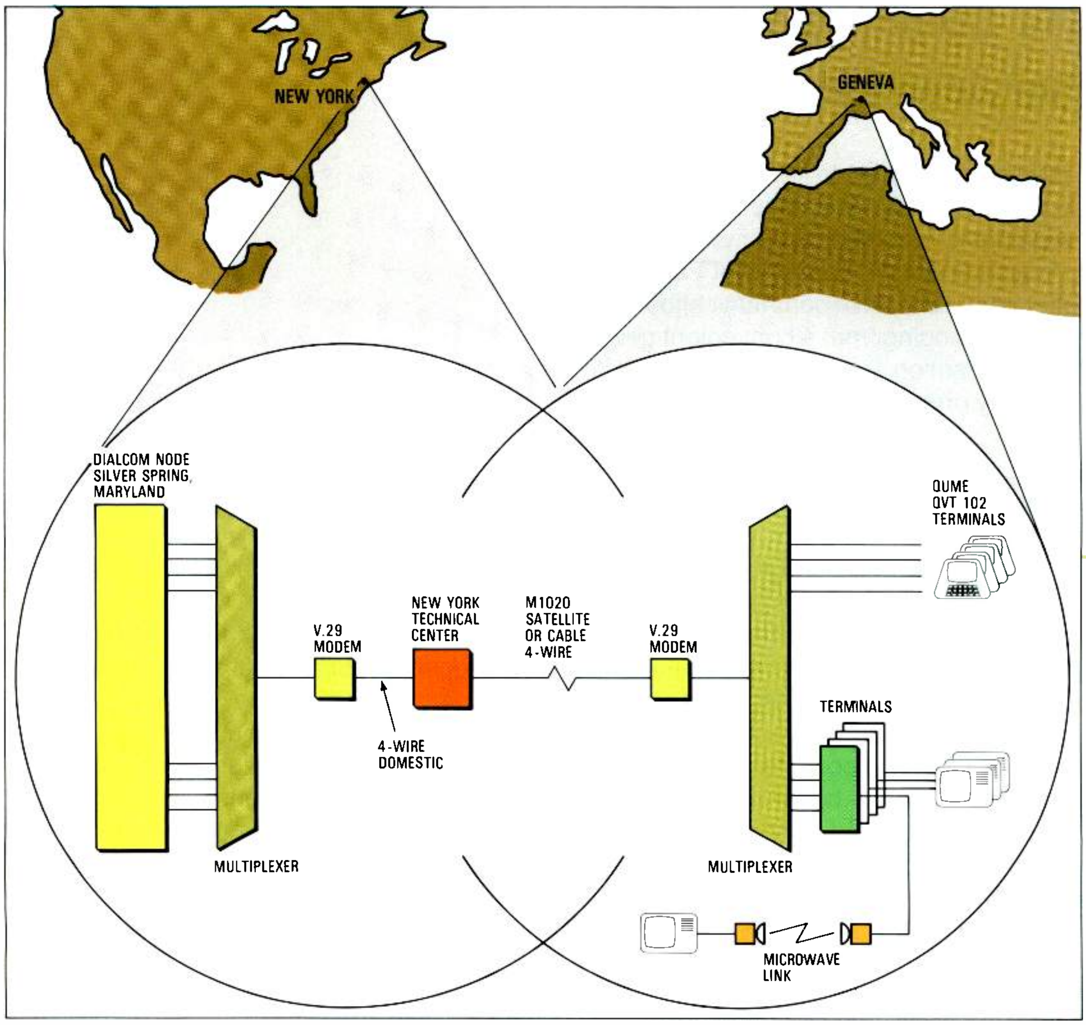


Figure 1
Schematic of ITT's electronic message center which connects the ITT corporate stand at Telecom 83 to the Dialcom database in the USA.

from any of the terminals into the Dialcom system where it is stored until retrieved by the addressed individual using a preregistered access code. Other information, such as news, airline schedules, and business information and statistics can also be retrieved.

Database Access and Universal Compatibility

The configuration uses one asynchronous terminal, an ITT Qume QVT102, and an ITT personal computer connected to ITT World Communications' packet data network (Figure 2). The point-to-point link is a 4-wire, M1020 transatlantic line with CCITT V.29 multiport modems at each end. The aggregate transmission rate of the modems is 9600 bit s^{-1}, with each port accepting 2400 bit s^{-1} synchronous data. A multiplexer connected to a port on the V.29 modem accepts data from both terminals. As the Qume is a 1200 bit s^{-1} asynchronous terminal, an asynchronous/synchronous converter is used. The matching ends in New York are connected to ITT Worldcom's UDTS (universal data transfer service). All interfaces to the modems, UDTS ports, and terminals are CCITT V.24/V.28 standard, equivalent to the EIA RS.232 standard in the United States.

Using this configuration it is possible for the asynchronous terminal to communicate with the ITT personal computer, and *vice versa*. In addition, either terminal has access to a variety of databases, and it is possible to link telex and data terminals.

Data is transmitted from the Qume QVT102 asynchronous 1200 bit s^{-1} terminal to the UDTS packet network. The message, correctly formatted and addressed, is processed by UDTS, its code and speed are converted, and it is then transmitted to the ITT personal computer. The reverse procedure is followed for messages in the other direction.

In the case of database access, UDTS has connections to various databases such as ITT Dialcom and UPDATE, and other data networks (e.g. Tymnet, Telenet), so connections are possible with the Qume asynchronous and ITT personal computer

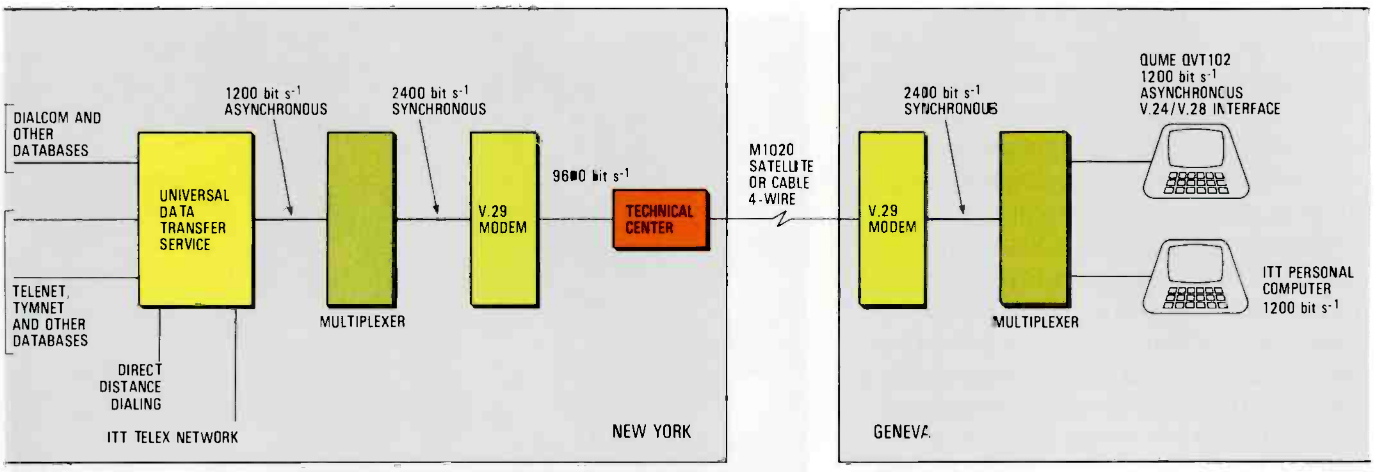


Figure 2
ITT Coins packet switched data network.

via UDTS databases and networks. At the same time, the terminals can access Viditel in the Netherlands to display electronic "Yellow Pages".

Finally, telex messages can be sent to the UDTS telex access port. UDTS accepts these messages, performs the necessary speed and code conversions, and transmits them to either the Qume terminal or personal computer, or both.

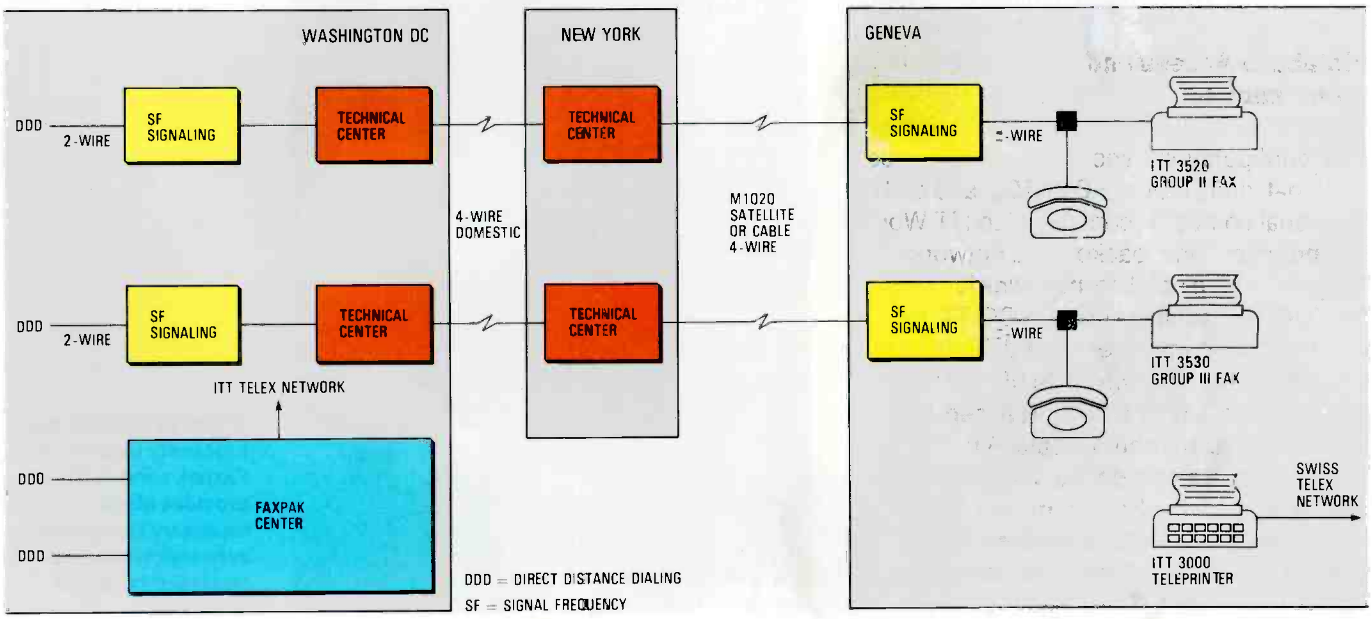
Faxpak Facsimile Service

ITT Worldcom's FAXPAK* facsimile service makes it possible for normally incompatible facsimile machines to communicate. As an example, Group II (ITT 3520) and Group III (ITT 3530) facsimile terminals on the stand are connected via the Faxpak network. In addition, when a telex message is transmitted via the Faxpak service, it can be delivered to any facsimile unit registered on the network.

Faxpak is a dial-in/dial-out system, so two direct distance dialing lines have been extended from Washington DC to Geneva. To realize this link, the lines are interfaced to signal frequency signaling packages that control the 4-wire CCITT M1020 specification transatlantic lines (Figure 3). In Geneva the signaling package is interfaced to the facsimile terminal and a dual-tone multifrequency pushbutton telephone subset. This subset is used to dial the Faxpak incoming port and to provide addressing, access, and authorization codes.

In a typical case, a Group II terminal may wish to send copy to a Group III facsimile machine which would not normally be possible. If both machines are connected to the Faxpak service, the operator goes off-hook at the Group II facsimile terminal,

Figure 3
ITT Coins Faxpak service.



detects dial tone, and dials the Faxpak Group II port. Faxpak then answers automatically and requests, in a digitized prerecorded voice, delivery information, authorization codes, etc. The operator transmits this information using the standard numeric keypad on the subset.

When all the information has been accepted, Faxpak requests that the document be transmitted, receives the document, and processes it for delivery to the Group III terminal. Faxpak then dials the direct distance dialing number associated with the Group III machine in Geneva, which in turn detects the incoming ringing condition, answers, and accepts the facsimile message. The equivalent operations occur for the Group III to Group II compatibility conversion.

In the telex to facsimile mode, the telex machine operator dials the Faxpak telex port. Faxpak responds with its answerback and accepts the telex message and delivery information; Faxpak then processes the message and delivers it to either the Group II or Group III terminal, depending on which one was addressed. Alternatively the system can broadcast the message to both terminals.

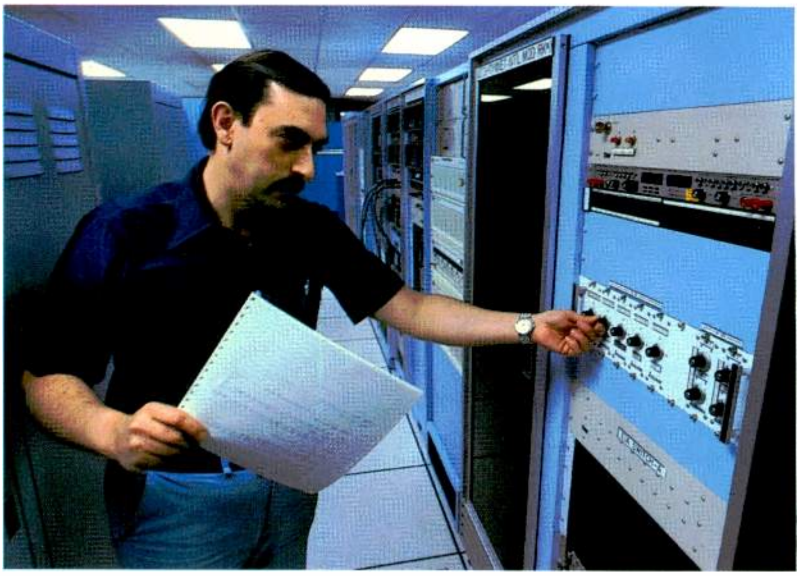
ITT World Directories

ITT World Directories, founded in 1967 and now part of the COINS group, is today the world's largest international producer of telephone directories outside the continental USA. The company works with the telephone Administrations in Belgium, Holland, Ireland, Portugal, Puerto Rico, South Africa, Sweden, the United Kingdom, and the US Virgin Islands, serving over two million businesses and 25 million telephone subscribers. Revenue is created exclusively through the sale of advertising in the Yellow Pages.

A major feature of ITT World Directories service is that it offers considerable flexibility in meeting the directory requirements of a particular country. The services offered range from consultancy agreements to a total turnkey operation. In each case, ITT World Directories can take care of the entire operation from sales of yellow pages advertising, through compilation and publishing, to distribution and billing.

A completely new computer software system simplifies the total directory operation. Known as DOSS (directory operating support system), it supports sales, production, distribution, billing, marketing, finance, and directory assistance, enabling many of these functions to be handled automatically. Other advantages of DOSS are that it provides more accurate information, facilitates constant updating and cross checking, and gives an immediate picture of the total operation. The system can be used anywhere in the world. Some of these functions are demonstrated at Telecom 83.

In the rapidly expanding field of electronic information systems, World Directories functions as an integral part of the ITT



View of the equipment used for the universal data transmission system – an international packet switched data communication service.

A view of the front end processor used for the Faxpak service. This provides all the necessary compatibility conversion between dissimilar facsimile terminals.

COINS group. Under the overall strategic direction of the group, studies are beginning of information products for distribution by telephone line, cable, and special purpose networks.

The first phase of this development covers all forms of electronic information for delivery to videotex, teletext, teletex, telex, and traditional "dumb" computer terminals. A second phase is aimed at products for intelligent terminals (management workstations and personal computers). Users will be offered a complete problem solving service tailored closely to each market sector, involving interactive transaction capability (e.g. via network gateways) and application software to work with the basic information products provided in the first phase.

Currently the company is involved as an information provider for videotex services in the United Kingdom (Prestel) and the Netherlands (Viditel), and is producing the official directories for both these services.

Aspects of these developments are being demonstrated at Telecom 83 using videotex format. An intelligent terminal provides off-line support, and direct connections are also available to public videotex services.

Typical display from the Viditel service in the Netherlands.

Key Technology Steering Group Forecasts
An Introduction

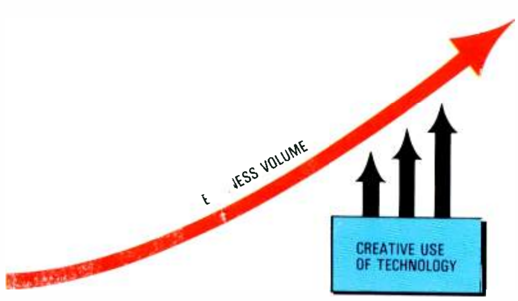
The author provides a view of advanced technology within ITT today; its role, how it is managed, how key areas are chosen, and some likely directions for the future. He also introduces a series of contributions on the way the chairmen of ITT's Key Technology Steering Groups see their particular areas of technology evolving over the next decade.

The Role of Advanced Technology

Throughout a modern forward looking corporation such as ITT, advanced technology is the lifeblood that provides high quality products and services. This is equally true for electronic equipment, pumps and valves, and in the service industries such as hotels and insurance. Without a thorough understanding of advanced technology and its creative application to business, a company cannot succeed in the future. The view that creative use of technology is absolutely necessary for the growth and prosperity of the corporation permeates down from the board of directors, through senior management, to the engineers and scientists who work on advancing the frontiers of knowledge, and who apply this knowledge to our products and services.

Application of Advanced Technology

In telecommunication and other areas which depend heavily on electronics, such as defense, the most important technologies are microelectronics (especially VLSI), systems technology, programming technology, and fiber optics.



Creative use of advanced technology is essential to sustained business growth.

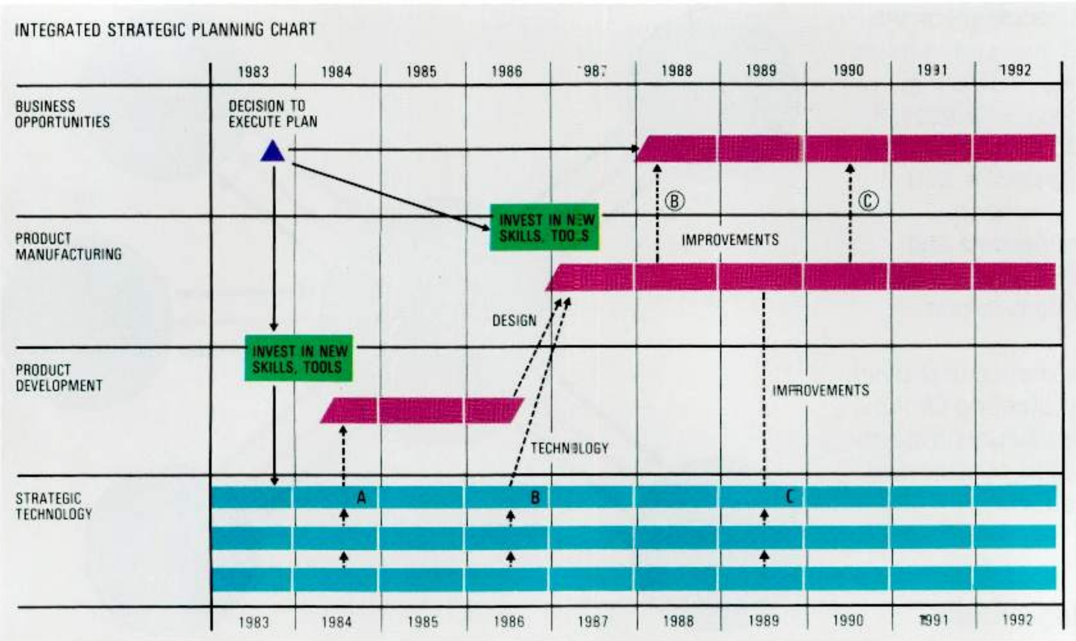
In addition, several applied areas, such as the intelligent products technologies, are important.

However, advanced technology extends well beyond the telecommunication area of ITT's business. Within industrial technology products, for example, the technologies with the greatest impact are the materials sciences, materials engineering, and computer-aided design of complex structures.

A prime example of the application of advanced technology to service industries is the sophisticated computerized reservation and operations system employed by Sheraton Hotels. This enables a customer to reserve a room at any Sheraton Hotel in the world, and business managers in the Sheraton Corporation to optimize Sheraton's operations. Another important example is the pervasive use of computer and programming technologies in the insurance and financial services fields.

Selecting and Investing in Key Technologies

The selection of key technologies is carried out in an evolutionary way, as technology itself evolves. Some years ago certain broad areas of advanced technology were selected as needing special emphasis, resulting in the current list of key technologies. Then, to ensure that ITT devotes the appropriate resources to these key areas and guides work in them effectively, a Key Technology Steering Group was set up for each area. The steering groups bring together, from ITT's worldwide operations, experts in the appropriate fields and managers experienced in applying technologies to



Integrated strategic planning chart.

business. Together they identify ITT's needs in each technology and define the R & D programmes required to meet these needs.

As these general categories are too broad to allow detailed planning, the most important *niches* were identified for each area; these are smaller technological fields that are clearly and directly applicable to a number of areas of ITT's business. For example, in VLSI there are niches of silicon technology, gallium arsenide technology, computer-aided design, and packaging. This approach makes it far easier to define our needs and the required future actions and programmes.

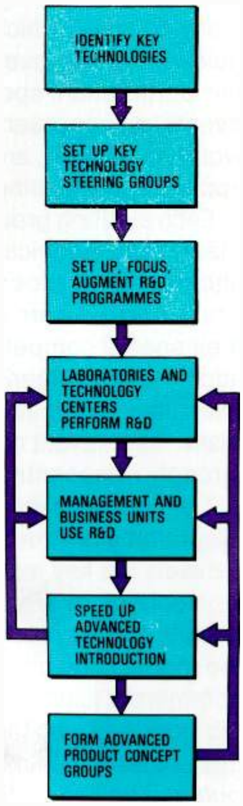
Having identified the important needs and future ITT users of a technology, decisions have to be made on the investment levels in each of the technology niches and on who performs the work. One approach that has proved successful is to use seed money investment for a start-up period, after which the areas needing larger and continuing investment can be accurately identified. Again using VLSI as an example, after an initial study period it became clear that major corporate strategic investments were required in silicon and gallium arsenide technologies, and these investments were indeed begun and continue.

Managing Advanced Technology

A major instrument that ITT uses for managing advanced technology is the Key Technology Steering Group, which has the task of formulating the R & D programmes that ITT needs to meet its corporate business objectives, and monitor and coordinate the programmes once they have been started. It is essential, therefore, that these programmes are fully understood and accepted by the senior managers in the companies that will use these technologies. This technique assembles a 'critical mass' of expert talent from ITT units throughout the world; the directions proposed by each steering group are then disseminated throughout ITT by the participants.

There are, of course, other management mechanisms. Several times each year the broad advanced technology strategy and programmes are reviewed personally by the Chairman, President, and Chief Executive of ITT. Once a year there is a major meeting of top management and technical leaders in the Corporation at which all the facets of employing and managing advanced technology are analyzed and appropriate actions taken. Several times a year the major parts of the programme are presented to the Board of Directors. However, advanced technology in the abstract does not help the profitable growth of ITT's businesses. To achieve growth, the output of the advanced technology programmes must be introduced into the products and services of the Corporation. This has become a major challenge and opportunity for technical management. A new planning tool, the integration chart, has been introduced throughout the Corporation. This brings

Management of advanced technology within ITT.



together in one planning document all the major management areas involved: general business management, manufacturing, engineering, and advanced technology. A comprehensive integrated plan shows the relations of decisions, milestones, and investment leading from advanced technology to the finished product and markets. This allows us to manage R & D by its output and its contributions to our business.

New steering mechanisms, quite distinct from the Key Technology Steering Groups, are being developed to plan future products and the effective introduction of advanced technology into these products.

Key Technology Steering Groups

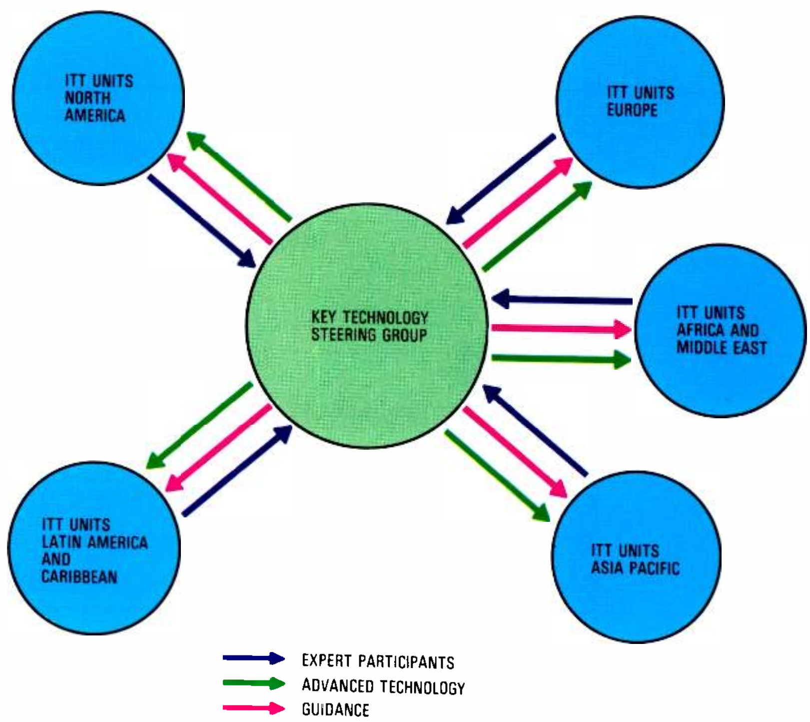
These steering groups were started some four years ago and have evolved over the years. They have a number of important features. One is that membership is truly international. This is essential in order to have a worldwide ITT approach to ITT problems. Meetings of the steering groups rotate between different countries to ensure that members of the groups are familiar with local conditions in countries where ITT has major activities. In this way it is possible to work out a consistent and coherent view of the problems and potential solutions.

Another important aspect of the Key Technology Steering Groups is that they really do steer, which means that they give guidance, affect events in relevant parts of the Corporation, speed up or slow down events, as necessary. This concept has worked very well, and is gradually being applied to a widening range of activities.

Each steering group is a closely knit team made up of technical people, managers, and marketing experts from within the Corporation. All are chosen on the basis of their special competence or expertise. In addition, each steering group has an executive committee on which those who make the relevant decisions within ITT are strongly represented.

The corporate research and development programme is structured in a way that parallels the key technologies. For each key technology area, an overall R & D case describes the objectives of the programme, the funding, the planned milestones, the commercial justification, who will carry out the work, and who the ITT customers are. In this context, ITT aims to manage R & D by *output*. The conventional approach is primarily to weigh the *input* to R & D in terms of funding, man years, and so on. However, from a practical viewpoint it is *at least* as important to be concerned about the output of R & D, even if the measures are harder to specify. Just what the Corporation is receiving from its extensive R & D effort is becoming increasingly clear, and this knowledge is built into our integrated planning approach.

To ensure proper coordination of the overall programme, several mechanisms are used. All chairmen and executive secretaries of the Key Technology Steering Groups meet together each month to manage the overall programme. In addition, a worldwide laboratory review is held each year. Finally, there is the increasing use of integration charts that show explicitly how the key technologies relate to each other and to future products.



Key Technology Steering Groups are an important mechanism within ITT for centralizing knowledge in advanced technologies, and then guiding ITT companies worldwide in their use.

Technical People

ITT considers the people working in the corporation to be its most important asset, and one that cannot easily be replaced. Experienced, creative, trained employees who work well together are an asset that takes many years to build. ITT is therefore taking new steps to help people to plan their careers, to highlight their goals for personal achievement and development, to improve facilities and working conditions, and to improve access to management.

ITT actively pursues education and training for its personnel. Technical personnel are encouraged and helped towards advanced degrees. There is an internal training programme, particularly in the rapidly evolving area of programming, where the aim is for all ITT's programming staff to participate in 20 days of advanced training each year. This programme is being expanded to other fields of technology.

A recently instituted programme designed to stimulate innovation and develop new technological opportunities is the appointment of ITT Executive Scientists. The mission of executive scientists is to take a long, hard look at new technologies that offer high promise for the business of the future, and to initiate work on research programmes in these areas. This appointment is for several years to ensure that there is time to obtain useful results. The first two recipients are Dr Charles Kao, a pioneer in fiber optics, and Dr James Dunn, a leader in speech processing technology.

Collaboration with Governments and Universities

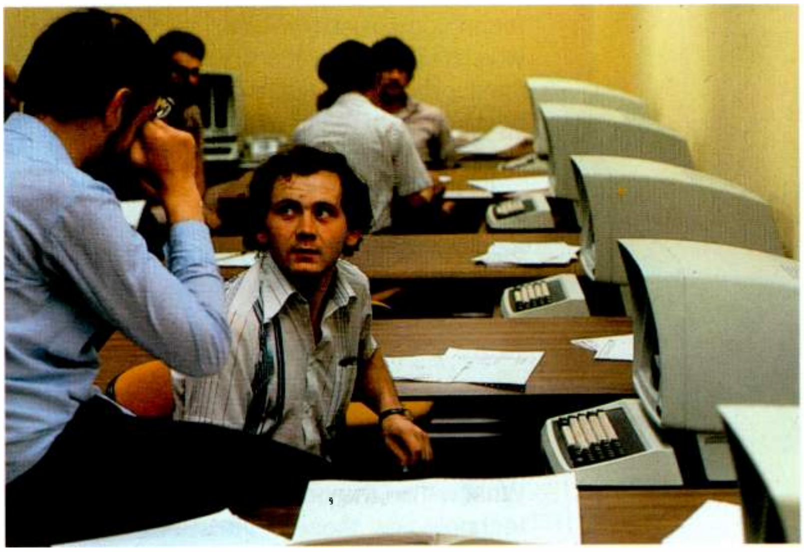
Even a company with the resources and diversity of ITT cannot undertake all technological developments alone. Thus ITT has established a number of arrangements with the university community to ensure fruitful and lively contact. For example, the company is a member of the Center for Integrated Systems at Stanford University, a new enterprise that is bringing together computer science, electrical engineering, and materials research in a way that will greatly benefit the electronics industry. As a second example, the Corporation supports a major R & D programme on integrated optics at the California Institute of Technology.

In addition to these corporate investments, individual ITT houses have negotiated hundreds of consulting agreements with universities all over the world. These are strongly encouraged and have proved of immense benefit both to ITT and the participating universities.

As well as working with universities on basic research, it is becoming increasingly important for ITT to work with governments and with other companies in areas of advanced technology. As examples, Standard Elektrik Lorenz is working with the government of the Federal Republic of Germany on new and creative programmes in advanced communication; Bell Telephone Manufacturing Company is involved in a joint venture with the Belgian government on microelectronics; and in the USA, ITT units have important R & D contracts with the US Department of Defense.

Technical Results

Many of ITT's significant technical achievements are evident in other parts of this special issue. However, several major results from ITT's approach to and investment in advanced technology are



Continuing education of technical personnel is important in many areas of advanced technology. As an example, ITT's programming staff participate in 20 days of state-of-the-art programming training each year.

highlighted here. The most important is the ITT 1240 Digital Exchange which is, without question, the most advanced electronic exchange of today, and designed to evolve to meet new needs. Several aspects of the ITT 1240 depend on totally new technology. One is the novel system architecture which is the result of the most advanced systems technology thinking.

A further dimension of the ITT 1240 which depends critically on advanced technology is the use of microelectronics. Key components, such as the switch port and line circuit, are proprietary ITT designs; they are manufactured by ITT and will evolve using increasingly advanced technology, making the system even more reliable, less costly to operate, and more economic to manufacture.

The third technological dimension of the ITT 1240 is its large and powerful computer program which is based on the most modern programming technology available today.

Again, as new and more powerful programming technologies are developed, the ITT 1240 program will be upgraded to improve the system performance even further.

In quite a different product area, a major technical breakthrough is the digital television system produced by Deutsche ITT Industries. This revolutionary system utilizes digital signal processing to simplify the electronics of a television set. It offers new possibilities for improved reception and clearer pictures, automatic adjustment, simplified maintenance, and sophisticated manipulation of the television signal to provide features such as a split screen.

There are many other examples of important developments in advanced technology. Just one is the materials area in which ITT has developed several proprietary metal processing techniques which are being used to manufacture improved products.

All these inventions are expanding the technology base which will be used as a platform for further development and improvement of ITT's products and services.

The Future

What will be the new advanced technologies, those of the 1990s? It is essential to plan now for these technologies, so ITT continues to invest to ensure the Corporations's continuing success in an environment that is increasingly dominated by advanced technology.

In a certain sense, most technologies depend upon materials science. Scientists are already studying how to build electronic structures one molecule at a time, and the realization of this may not be very far away. Such structures will offer device densities and circuit complexities that are barely imaginable even in the present era of VLSI. Another facet of this technology will be greatly increased speeds because transit times will be very much shorter. At the same time, these new structures will require new approaches to the characterization of system architectures. Future systems may approach the complexity of certain subsystems of the human brain. The result is likely to be quite astonishing progress in system and product capabilities and reliability.

Another technology that will be very important is integrated optoelectronics. In the near future it will be possible to build systems that use optical, electronic, and acoustic techniques to process information. The actual combination of these techniques in future systems will depend both on the task and on product economics.

Still another dimension of future technology will be the advent of artificial intelligence or, somewhat more narrowly, rule-based systems or expert assistance systems. The next 10 years is likely to see the emergence of office systems, for example, which will be based on many semi-autonomous computer systems all working together at whatever task the users set for the system. There will be much easier interaction between users and the system, and between users through the system, using both speech and graphics. Realization of these systems may be much nearer than most people believe, and ITT is laying the foundations for progress in this area.

Computer-aided design and manufacture will have an even more remarkable impact on business in the future than it has had to date. In particular, the integration of high-level design, full engineering design, manufacture, test, and servicing into a closely integrated, computer-based system will take place. This will improve creativity and productivity, and will make it possible to produce more advanced products.

The developments described in this article will occur over the next ten years or sooner. Others not presented here, or as yet not even guessed at, will also be realized. Together, these developments are part of the second industrial revolution, and this will transform human society as deeply as did the first industrial revolution. These developments will also change ITT as it strives to help people and their societies with better ideas, products, and services.

C. Herzfeld
ITT Vice President and Director of Research and Technology
ITT Headquarters, New York, USA

Designing the Systems of Tomorrow

The sheer complexity of tomorrow's systems requires completely new approaches to system design. It will be necessary to realize new description languages and harness the power of the systems themselves if the progress is to be made that will allow the full potential of systems technology to be achieved.

Introduction

Standing between us and the systems of the future is a barrier higher and more formidable than any that has faced us in the past decade: *complexity*. Think of the time and effort that went into the creation of the ITT 1240 Digital Exchange – a system that stands at the forefront of modern telephone and computer systems. Now think of an "ITT 1240-on-a-chip". In the world of electronic systems, the multimillion gate chip is within reach. The designers we are training today will create such systems, and the tools we build today must support such designs.

The first mass-produced integrated circuits had a complexity roughly similar to a few hundred square meters of a city plan. In LSI (large scale integration) the complexity matched several square kilometers of the city plan. A single architect, perhaps with the aid of a draughtsman, could create such a plan. Now with VLSI (very large scale integration) the analogy is with a map of an entire city.

In the United States, the first example is sometimes likened to part of San Jose, the city at the heart of "Silicon Valley". The second view is most of San Jose, while the third is almost the entire valley.

The problem is, how can a designer, or even a small group of designers, create a VLSI design of such complexity? Then go beyond the circuit itself and look at the *system* which is much more than a circuit.

Futurists who are in love with VLSI, as well they might be, are afflicted with the "on-a-chip" syndrome: ITT 1240-on-a-chip, office-on-a-chip, library-on-a-chip, stock-market-on-a-chip, and more. However, a system is more than hardware; it is hardware, software, microcode, user interface, documentation, and training. It is the result of analysis, testing, tradeoffs between cost and performance, and tradeoffs between implementation methods. It is an aggregation of parts and functions too complex for any one person to understand fully (Figure 1).

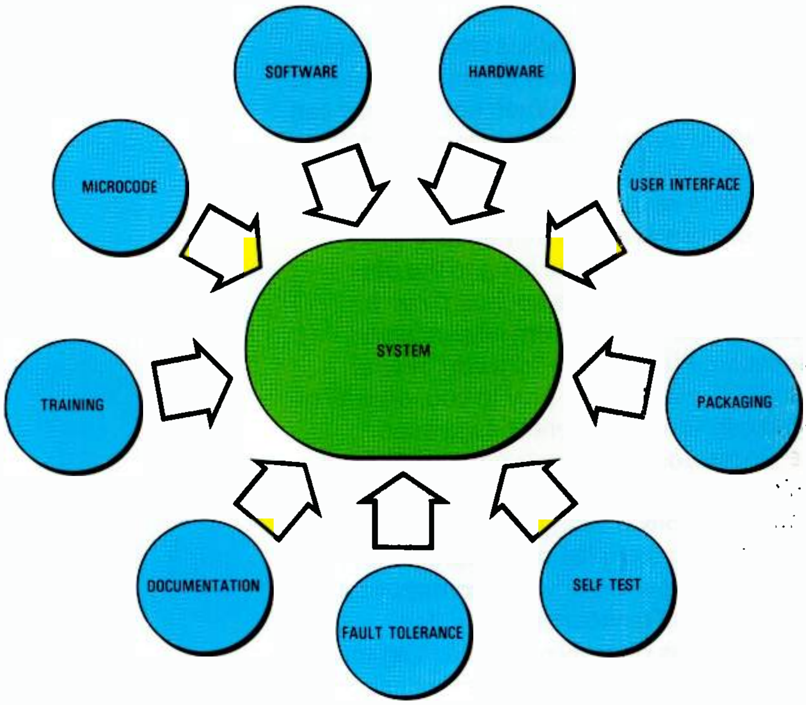
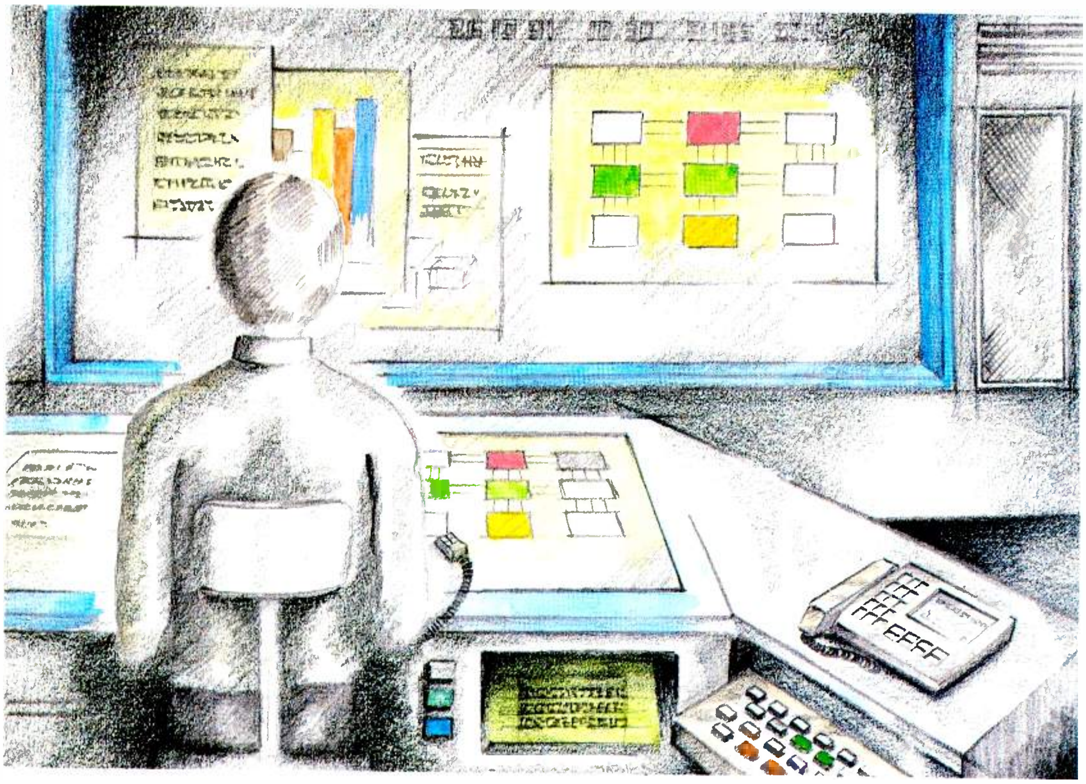


Figure 1
Major system components.

Office Scenario

Consider, as an example, an office system of the future. You arrive in the morning and the office greets you by name. Perhaps you used your identification code to open the door; maybe the system recognized your fingerprints as you opened the door, or detected your footstep and breathing patterns. You respond partly out of politeness and partly to allow a voiceprint check of your identity.

Now you sit at your desk and ask "What's on today?". The voice response tells you of your first appointment and reminds you that your boss asked you to call. At the same time, your calendar and agenda appear on a flat panel display that forms the desk top.



In the office of the future many functions will be automated. Paper will be replaced by versatile flat screen displays; speech recognition will make the system much more user friendly, although keyboards and other input devices will continue to be used.

Today, many software systems allow users to select an action from a "capability-based" menu which lists all the tasks that can be performed by the particular computer or program being used. An improvement is the "activity-based" menu, or agenda, which presents alternatives that reflect the tasks at hand. It is a combination of calendar, memo pad, phone call list, and personal reminders. This is the menu of future systems. The agenda is a basic user-interface tool for the integrated design system now under development at the ITT Advanced Technology Center. It is an example of the more general coordination systems technology being created at the ITT Programming Technology Center.

Returning to the scenario; you place a call to your boss. Although you initiate the call by speaking aloud, you pick up a telephone handset for the conversation to ensure privacy. She is out, but her telephone answering machine, part of the office system, informs you that she wants to schedule a project review next week. You ask the office system to set it up for Tuesday or Wednesday. After checking the diaries of all concerned, you are informed that the only way to have everyone there is to postpone a trip. You agree and the office system sends appropriate messages to the travel department. Next you select an item from the agenda. Perhaps you are reminded that sales brochures need to be finished: "Show me that memo I was working on last week just after I went to lunch with Tom, ... or was it Jack?"

It is important that the office of the future supports the functions of today, or there will not be a smooth transition to the functions of the future. This is not to say that functions will not change, but that any change will be evolutionary.

What does the office system look like? It is not a VDU and keyboard sitting on the desk: it probably is your desk. A major part of the desk top is a flat panel with text and graphics displays in full color showing many pages of text.

One of the office walls is also a flat display screen which can show all or part of what is on the desk display. When not in use, it can show a favorite picture. While most of this scenario has had you conversing with the system, a keyboard and other interaction devices are available and equally convenient: the mode is up to the user. When necessary, the keyboard can be swung into position from its concealed location. Pulling out a "drawer" reveals a small display, visible only to you, on which you can view confidential databases.

So far, you are the only person involved in the tasks; all functions have been carried out by the office system. In a group activity, the office system handles coordination, establishing voice or video communication as needed. Transcontinental video conferences offer relief to an aching travel budget. Regular tasks – weekly financial reviews, for example – are coordinated by the system which informs contributors when their parts are due, and reminds them when they are overdue. Components are then put together, passed to the (human) editor, and published automatically.

A pessimistic vision of the future sees reports created by computers, distributed by computers, received by computers, and stored by computers in files that no human ever sees. Data is the bits, bytes, numbers, and words stored in computer files. Information is that small part of the data that is useful to people. The office system of the future should increase information and decrease data.

This scenario has provided a glimpse of one part of one future system. Similar predictions can be made for other areas: education, transportation, and medicine to name but a few.

System Design

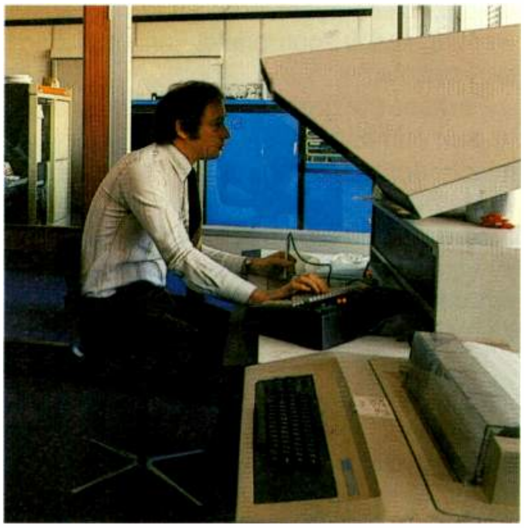
The problem remains, how can such systems be designed?

The answer is simple; obvious in concept, but overwhelming in detail. The computer will help design tomorrow's computer-based systems. Despite many advances, industry is late in creating tools and technologies capable of handling the complexity of tomorrow's system designs. CAD (or CAVD or CAM or CADEM) is part of the answer, but is far from being a complete answer. Tools are also needed to translate dreams into designs – demonstrably correct designs. As a result of work at ATC, PTC, BTM, ESC, and STL (to name a few), ITT is at the forefront of design methods. However, we have barely scratched the surface of the abilities tomorrow's design tools will need.

Another scenario may help to describe how systems will be designed. Needless to say, a design system will support the designer of the future. Let us suppose that a *customer* comes to a *designer* with an idea for a product. The customer has an idea, a dream, a concept, perhaps a plan, while the designer has the ability, the know-how, the experience, and the tools, to translate the wish into reality.

The customer and designer confer. Eventually the designer translates the informal definition into a formal specification based on logic or mathematics. It may be graphical, using a notation like the Galileo language developed at the SESA Research Center in Madrid.

However it is annotated, the customer is unlikely to be able to read the formal definition directly and make any sense of it. However, a process called *animation* enables the designer to show the customer how the system behaves. Animation is a high level simulation process that can display system behavior before detailed design. The success of animation depends on the correctness and the completeness of the definition. By allowing the eventual user of a system to exercise it directly from the high level specification, the correspondence between the original dream and the beginning of the design can be established. The formal aspect of the definition allows the designer to prove correctness, lack of ambiguity, and lack of internal contradictions. Animation will



Today, ITT is at the forefront of CAD and CAM techniques, but has still barely scratched the surface of the capabilities of tomorrow's design tools.

provide a set of test cases that can be used repeatedly on the system during the various design stages.

It is unlikely that there will be a single designer doing the top level definition. Certainly in the succeeding stages of design there will be a team – a group of people cooperating to translate the specification into a product. Eventually the design group will work in a totally automated environment not unlike the office system described above, but today and for the next few years they will use engineering workstations.

The workstation is a powerful single-user computer with display, keyboard, disk, pointing device, and a network interface to other workstations. It may be connected to a mainframe computer, but this is becoming less and less necessary. A workstation is a major step beyond the timesharing terminal in use today.

The workstation – or properly a network of workstations (Figure 2) – is the design environment of the future, providing design assistance, as well as communication and coordination facilities between the design team members. It will also be the a tutor to the novice and at times an expert adviser. Figure 3 shows some of the attributes and abilities of such a system.

Advanced Design Environment

Just as the office system must support all office activities, the design system must support all the activities of the design engineer, including the day-to-day tasks of documentation, planning, and group communication.

PERT-chart monitors may automatically track the parallel and sequential paths of actions and events, reporting, reminding, warning and, if appropriate, congratulating participants.

Perhaps the greatest flaw in human-to-human communication is misunderstanding. We talk and come to an agreement, but later find that we cannot agree on what was agreed. When the design system coordinates an assignment or agreement, it will annotate a textual description of the acceptance or agreement.

Word processing will be intrinsic to documentation. Only by including documentation throughout all phases of the design cycle can completeness and correctness of the design be assured. Some in the programming community feel that full documentation – including the reference manual for the regular user as well as tutorial manuals for the novice – should be completed before coding begins since the cost of revising documents is less than the cost of rewriting code. This principle should apply to all systems.

We have learned a lot about the ergonomics of the human-computer interface. Physical ergonomics are important, but psychological human factors are just as important. Working at a project should not give you a frustration headache. Documentation should be readily available at the screen. An intelligent helper should be able to answer important questions such as "What would happen if?" "How do I?" "What did I do to cause?" "How did I get here?".

Design Tools

One essential requirement of all future design tools will be integration. It must be possible for the outputs from one tool to be fed into the inputs of another without the user worrying about format differences. Command structures should be the same, as should the formats and conventions of pictorial displays. Briefly, some future design aids will be:

Simulators and animators: Today protocol simulators and logic simulators are available, but in future simulation or animation will be required throughout the system design with the ability to mix levels. A system under development with parts in hardware, parts in logic diagram, parts in software, and parts in formal specification will be animated to show how it behaves.

Compilers and synthesizers: If the specification is precise enough, implementation should be automated. The beginnings of this are already evident in program generators and "silicon compilers". The latter are programs that

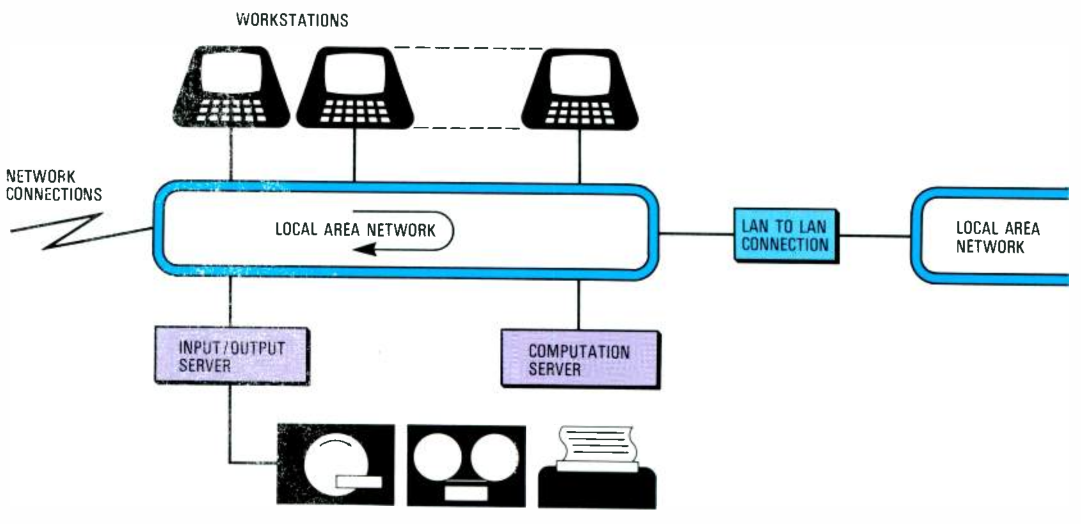


Figure 2
Workstation ring based on a local area network.

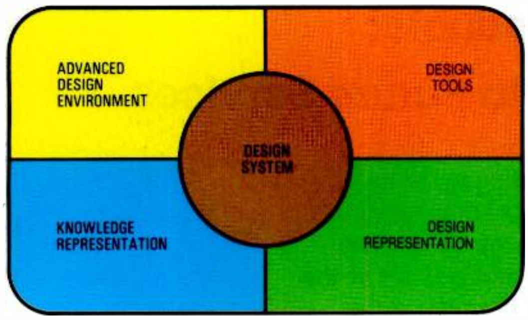


Figure 3
Design system components.

translate a high level specification for a system into a detailed, correct LSI layout. Already silicon compilation based on logic specification is being developed; eventually compilation will be performed directly from the high level system specifications.

Verifiers: A system is correct when it does what the user wants it to do. As long as the requirements are precise, correctness will be determined automatically.

Performance analyzers and optimizers: Human effort should be devoted to making sure that the system being designed does what is required. Making it do so cheaply and efficiently will therefore be automated.

Design Representation

At present, natural language is the only way of providing a complete system description. Languages or notations are needed that can describe requirements, performance, and behavior precisely without constraining the final method of implementation. They should be verifiable and capable of animation. Despite progress, considerable further research is needed.

Knowledge Representation

We have progressed from data processing to information systems; the next step is "knowledge engineering". This is more than a buzzword; the technology and "seat-of-the-pants" engineering that characterize today's artificial intelligence are finally becoming usable in production programs. Some of the artificial intelligence based tools of future systems will be:

Syntax-directed editors for helping to enter information, text, or diagrams, into the computer. If knowledge about the subject is built into the editor, it will be able to assist the user and prevent errors.

Design history: As a design progresses from an idea to implementation, designers make many decisions and test many alternatives. A design system should maintain a complete record of the changes, including the reasons for them.

Design advisor: The intelligent computer design advisor will be an expert consultant and resource for the designer. It will store a large base of design knowledge and give advice or make suggestions when asked.

When?

All the above is promised for "the future", which is very vague. To some extent the future is here. A generation that takes the computer for granted is now graduating from schools and universities and entering business.

Recently, there has been a change that, in my opinion, heralds the true computer revolution. Computers are now sold not as special-purpose wordprocessors or CAD systems, nor as machines for which programs must be written. Today they are devices on which to run purchased software. The computer revolution will be complete when a decision on buying a computer is made on the range of programs available, not on the programming capabilities.

Computers will be commonplace to our children. Today we are trying out the precursors of the future systems which our children will create and use.

Richard L. Wexelblat

R. L. Wexelblat
Chairman, Systems KTSG
Director, Integrated Design Methods and Tools
ITT Advanced Technology Center, Shelton, Connecticut, USA

Intelligent Products: the Doorway to Future Services

Evolution in communication systems is opening up a vast range of new services both for business and in the home. The user's doorway to these services will be the intelligent products and systems of the future, which will have to offer a user friendly interface for those not used to operating computer-based systems.

Introduction

In response to the progress of semiconductor, materials, and programming technologies, intelligent products are evolving in several ways. Intelligent products are becoming more intelligent and intelligence is becoming less expensive. Consequently, users needs are changing, and indeed new types of user are being introduced to such products in the office and at home. These trends and their mutual interactions have to be understood before it is possible to talk about future intelligent products and related technologies.

Intelligent product technologies address the systems that will enable users to take advantage of these basic technologies. They represent a technological interface between continuous advances in technology and changing user requirements.

Increasing Intelligence

Increasingly powerful microprocessors together with cheaper and smaller memory chips have resulted in a clear trend towards distributed processing in more intelligent terminals and away from shared central processors and "dumb" terminals. Terminals are becoming ever more independent with their own storage and computing capabilities. In turn this trend is altering communication requirements; increasingly the need is for communication between workstations in order to exchange entire files and programs.

The future will see a continuing trend towards cooperation between workstations, which may be widely dispersed, on a common task. The advent of optical storage technology will provide the last missing link on the way to electronic mail – that is, the "paper" of the paperless office.

Not only the internal structure and architecture of data and text processing and communication systems will change with increasing processing power and higher processing speeds. New applications will become possible. Speech recognition will allow direct voice control of computers which, as they become more and more powerful, will offer decision making capabilities. Increasing intelligence will make "expert" machines particularly valuable tools for human experts.

Lower Cost Intelligence

At the same time as smaller semiconductor feature sizes on the chip are increasing the power, speed, and complexity of processing, they are also bringing processing facilities within the economic reach of a much broader range of users. Personal computers have already penetrated the realm of small businesses and independent professional users. Undoubtedly this trend will continue as home computers, which today are little more than games, become ever more powerful and acquire comprehensive communication facilities. At that time, home-to-home electronic mail will not be far from realization.

Some public information systems such as teletext and videotex are aiming at the broadest user population. Towards the end of the 1980s, new fiber optic networks may connect private households to computers and information systems. These wideband, multifunction, interactive systems will bring

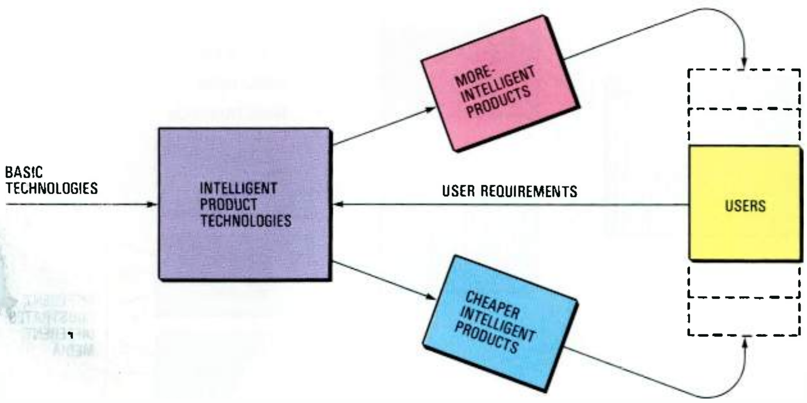


Figure 1
Intelligent product technologies are the interface between continuously advancing technology and changing user demands.

the man-machine interface to an extremely wide section of the population, including housewives and children.

The German Bundespost's BIGFON project is such a system. This fiber optic network will enable individual households to watch up to four television programmes simultaneously, selected from a wide range of available programmes, and similarly choose four simultaneous stereo audio programmes. Services will include videophone (using the telephone, TV receiver, and camera), teletext, videotex, several simultaneous telephone conversations, and data, text, and graphic communication.

The Changing User

The family of users and range of applications for computer-based systems is dramatically increasing in two directions: towards expert machines for specialist users and towards the home user. Clearly, the computer-based environment is affecting the user and his needs. As the invention of the copier generated reams of paper, the advent of low cost, mass storage will generate vast quantities of information. In the past, one concern of the manager was to obtain vital information as rapidly as possible; in the future a vast range of information will be at his disposal, and a main concern will be to locate and access all that is relevant.

It will not be sufficient simply to retrieve information by keywords, dates, and subjects. Managers will require intelligent information processing machines that can select relevant documents and process them, combining, comparing, drawing charts, establishing trends, producing graphics, and presenting them in a form that is easily assimilable and suitable for immediate use.

Few executives are comfortable using a keyboard. Frequently their idea of an "executive computer" is a machine to which they can talk, and which will respond in a human voice. However, the next generation of executives is already growing up in an environment in which television games and home computers are as familiar as the telephone. Thus in the longer term, speech recognition and voice synthesis will be employed where they are needed – for example, to assist airline pilots and in public information services – and less as a replacement for the keyboard.

Neither the secretary, nor the expert nor the general manager wishes to be replaced by a computer. What they need are tools that will make their work less arduous, faster, and more accurate. Such experts wish to remain experts in their own fields, and not in the use of computers. This will make it essential to apply human factors engineering to the design of the man-machine interface, thereby optimizing it for the widest possible range of users.

Security against loss of or unauthorized access to information, problems of social isolation caused by spending all day looking at a screen, and the ability to work with several workstations and operators simultaneously on a common task are also of major importance in determining human acceptability.

Technologies

Some of the key technologies that will affect the 1985 to 1990 timeframe are:

- display technology
- speech processing
- storage technologies
- human factors engineering
- local area networks
- new communication systems.

ITT has made good progress in high resolution, smectic liquid crystal flat screen monochrome displays with 300000 pixels on a 14 inch (diagonal) screen. Such displays will open up an entire range of new applications. For example, it has been proved that the productivity of skilled office staff can increase by as much as 30% when they are able to consult up to four full screen displays simultaneously, avoiding the need to switch backwards and forwards between the menu, reference documents, and the work document. Flat screens could be placed horizontally and used as desk tops. Flat displays will have particular advantages in portable applications, effectively allowing a user to take his office with him wherever he may be.

The display generation after the next will offer even higher resolutions, probably several thousand lines, and offer video write speeds, gray scales, and color capability. To make very large displays economically viable, they will have to be manufactured using a low cost technology such as printing. This will make it possible for slide and overhead projectors to be replaced by wall-size flat displays. It does not make much sense to produce complex charts in full color using the graphics capabilities of a personal computer, and then have to produce color slides for presentation at a conference.

Two problems that must be overcome before large displays become viable are the high cost and slow speed of driving circuits, which can cost up to five times as much as the display itself. Increasing resolution means that more lines have to be connected to drive LSIs, while increased multiplexing slows display response times. New interconnection and drive technologies are needed – preferably ones that could be printed on the same substrate as the display.

Storage Technology

Several technologies are competing to become the high density, low cost mass storage device of the future, which will be basic to any future computer or office system. The most promising technologies are write only once or DRAW (digital read after write), and erasable and rewritable disks. The two types are not necessarily in competition. For certain applications, such as legal, banking, and archival storage, non-rewritability is indeed an advantage. Also, when changes are infrequent, new data can be written in new memory locations and old data voided. With disk capacities of several gigabytes and costs of 10^{-3} US cents per A4 typed page, this will be an acceptable practice.

Features that will determine which of these technologies will survive and for what applications are:

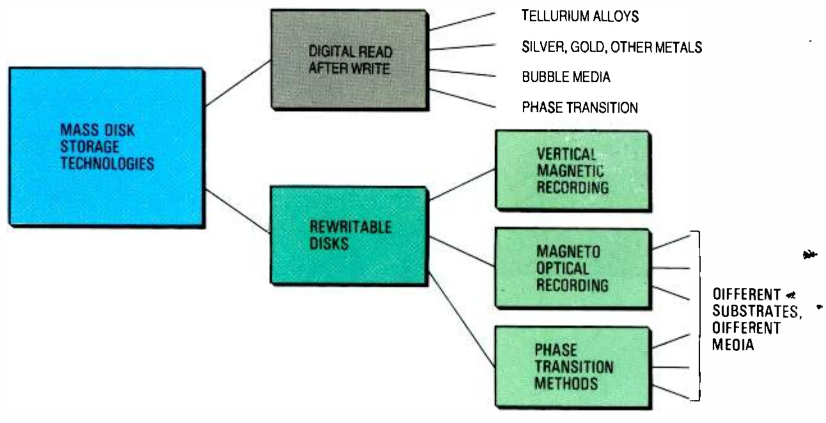


Figure 2
Mass storage technologies.

– storage capacity (generally 1 to 5 Gbytes)
– write/read data rate (about 10 Mbytes s^{-1})
– bit error rate (required 10^{-10} for data, 10^{-7} for analog)
– access time (typically 0.1 to 0.3 s)
– storage life (10 to 30 years required)
– cost of hardware, cost of disk (as low as $10).

These new storage media will obsolete present database management principles, which usually minimize memory

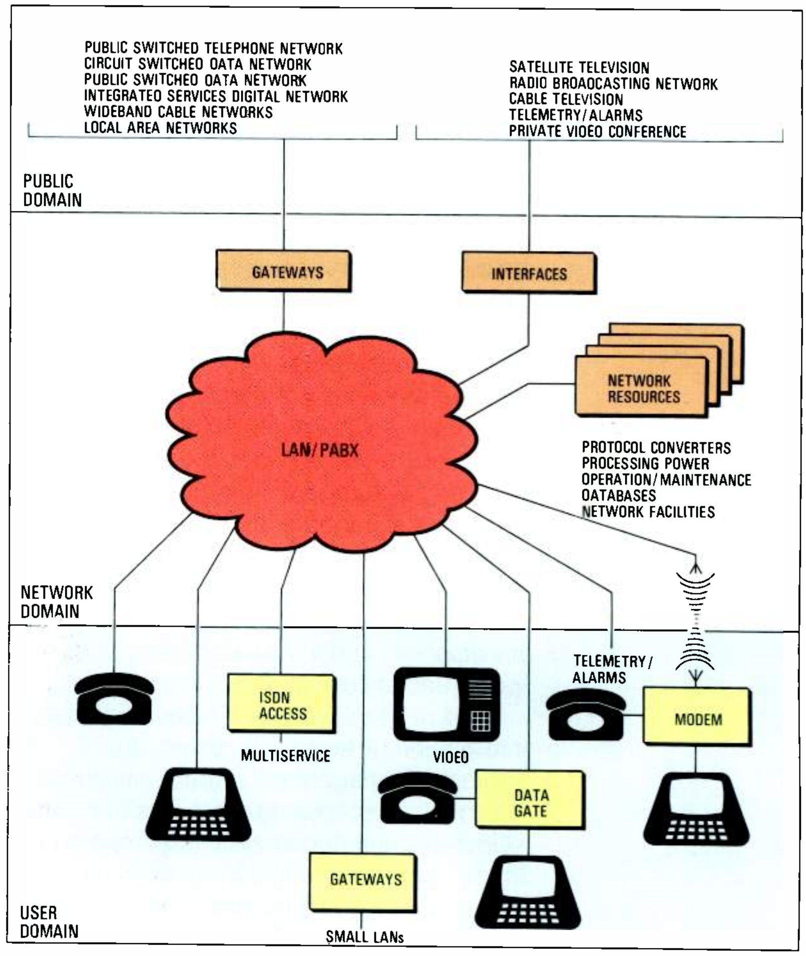


Figure 3
Conceptual model of a local area network.

requirements. Memory used to be expensive and access often slow, but when memory costs virtually nothing, new principles of filing, cross referencing, searching, and scanning will become necessary. Several million A4 pages of outgoing and incoming mail can be stored in data format on a single disk. Incoming "hardcopy" mail, drawings, and so on, will be stored in analog format, with several tens of thousands of items on one disk. High accuracy optical character readers will be necessary to simplify the filing, recording, and identification of analog documents.

Local Area Networks

The construction of an integrated office communication system must be based on the services offered to users. Today the most commonly needed services are interactive terminal access and text file transfer, neither of which requires very high speed communication. However, this situation will change as intelligence is distributed to multifunction workstations and intelligent network servers, and graphics is mixed with text information. There is a general trend towards services that require higher speeds, shorter response times, higher throughputs, and better quality of the underlying network.

Until about 1988, PABXs will be used primarily for voice communication. However, "third generation" PABXs will provide extensive voice, text, and data facilities, and further evolution will add graphics and image capabilities. At the same time local area networks will add voice capabilities, and the two products will eventually converge.

Human Factors

As mentioned earlier, human acceptability is of decisive importance to the effectiveness and success of a product. Increasingly, social and legal pressures are affecting the area of user interaction with terminals. For example, Study Group II of CCITT is considering questions in this area (human factors aspects of user interactions in computer based systems in international telecommunication), and the European Economic Community is considering adopting the German DIN standard on the use of VDUs.

Nine out of the 17 significant events contributing to the Three Mile Island nuclear power station accident in the USA were attributable to poor system design causing information overload. The field of artificial intelligence is developing techniques for human information processing which can improve the quality of interaction between man and machine.

As computer-based systems are becoming cheaper, they are being used by people with little knowledge of such systems. These users expect the product to be efficient, safe, and friendly.

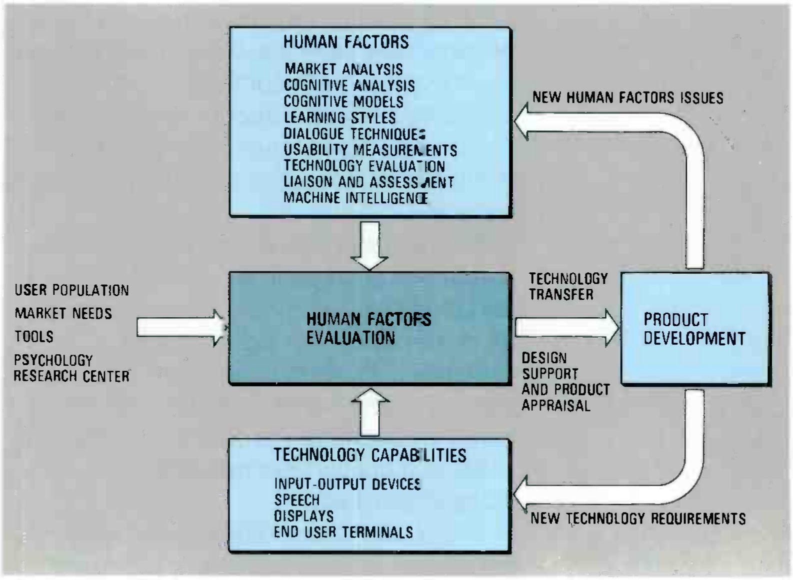


Figure 4
Role of human factors research in future product development.

Speech Processing Technlogy

The evolution of high speed VLSI circuits coupled with breakthroughs in linguistic understanding and processing techniques has produced enormous progress in computerized recognition, synthesis, and processing of speech signals. By 1990, commercially available speech input/output devices based on this technology will be small, inexpensive, and able to recognize large vocabularies (hundreds of words) of continuous, naturally spoken speech with accuracies better than 95%. They will operate with independent speaker inputs and provide a natural human format for the user-machine interface.

Potential applications include handsfree operation of terminals, voice telephone dialing, and enquiry and directory assistance systems. This technology also offers enormous potential for aiding the handicapped and in educational and learning systems.

Future Communication Systems

Existing voice, data, and entertainment networks can be expanded by the addition of many new services. Several of these are already available in some countries, including teletext, videotex, and teletex. The introduction of the ISDN will further widen the multifunction utilization of existing networks.

The next step will be the simultaneous transmission of graphics with voice over a telephone line. Another future service will be textfax which will add graphics capabilities to teletex. However, it is uncertain whether slow motion (narrow band) videophone will develop before new, wideband optical fiber networks offer full video capabilities.

At the start of the 1990s, many new networks will be in operation: wideband interactive systems such as cable television and the Bigfon system will go hand in hand with direct broadcast satellites and cellular radio.

All these systems will require new terminal technologies, faster and lighter terminals, faster and better quality printers with graphics capabilities, optical character readers, and intelligent scanners.

There is an exciting ten years ahead, with technological breakthroughs likely in nearly all areas of office, factory, and home life. As far as many users are concerned, these will be mainly characterized by the terminals they will use to access the new services. Today users see the telephone subset as the symbol of the public switched telephone network; tomorrow the intelligent terminal will symbolize the multifunction networks and services of the future.

D. Ilkovics

D. Ilkovics
Chairman, Intelligent Products KTSG
ITT Europe Inc, Brussels, Belgium

Future Technologies in Programming

New programming technologies are essential if full advantage is to be taken of the processing power and memory that will become available when VLSI feature sizes reach the 1 μm [illegible] It will be necessary to introduce new [illegible]s of program specification an[illegible]n, management, and testing, and to develop improved methodologies and architectures.

Introduction

One of the most significant long-term activities in the programming industry is research into ways of improving the performance of the individual programmer and the quality of delivered programs. ITT's two primary programming goals during the next five to seven years are a tenfold increase in programmer productivity, and zero-defect programs. Clearly, the attainment of goals as ambitious as these calls for a major research commitment. The effort is being coordinated by a Programming Key Technology Steering Group composed of programming managers and technical people in ITT units that have major programming activities. Under the direction of this steering group, esearch is going forward in six critical as, called "niches".

ese research programmes will provide ogy for the practical applications ry to the attainment of ITT's ing goals.

Approach

One important means of maximizing productivity and quality is the coordination of system technology[1]. ITT is at present developing future programming environments, comprising specialized tools and facilities to support programming-related tasks. This project also addresses the much more fundamental problems involved in coordinating the activities of groups of personnel engaged in a single cooperative effort. The fundamental element of future programming environments is a new coordination system. Whereas traditional programming environments are based on a conventional operating system, a common database, and the primitives file, program, directory structure, and process, ITT's concept involves a set of new, theoretically-based architectural primitives: role, action, and interaction[1].

The approach is derived from the trend towards the application of loosely coupled or distributed systems as an important new mechanism for coping with project complexity. It is easier to develop new system components than to ensure that they function well together. Thus the approach focuses on integrating the capabilities of a set of tools rather than on developing the tools themselves. The next generation of computers will provide for the effective utilization of large numbers of parallel active computing elements. This will result in a highly concurrent architecture which will allow major increases in performance as compared with present, tightly coupled, multiprocessor machines.

Programming Key Technology Steering Group Niches

In support of this and other approaches to improving productivity and quality, research is progressing in the six areas shown in Figure 1.

The *specification, analysis, and design niche* focuses on the development of facilities that aid in requirements analysis and in design. It also addresses the integration of such facilities into the overall product development lifecycle so that these tasks are not performed in isolation but yield work products that will be useful throughout the development process.

The *programming management niche* is concerned with developing tools and methods for the management of large projects. A major focus of this niche is the integration of tools and methods, personnel, and information use that is well beyond today's standard.

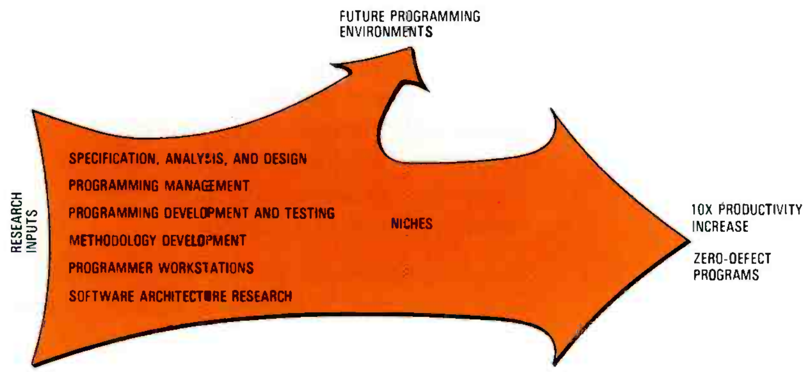


Figure 1
The ITT programming research strategy.

The *program development and testing niche* creates facilities to support the programmer. This is the area traditionally referred to as "programming", and includes such topics as programming tools, reuse of existing software and tools support for such reuse, program generators, target system simulation, and isolated and integrated testing.

Methodology development deals with the application of defined methods of software production to each sta of the lifecycle, recognizing that there a multiplicity of both methods and models. One objective is to prod template methodologies (reusable methods) for use within programming environments.

Another niche is devoted to *programmer workstations* for all kinds of programming personnel, including not only programmers but also managers, secretaries, and designers. This niche is concerned with the properties of the workstation itself, and thus with such hardware and software issues as network facilities, workstation operating systems, and support software. The niche is also concerned with the workstation as a user-system interface, and thus with such matters as user-computer dialogue, input/output devices, and human factors in general.

Research in the *software architecture niche* will promote the development of architectures and the understanding of how to describe, analyze, and fit an architecture to the requirements of potential applications. A further objective is to determine an appropriate architecture for ITT's future programming environments.

Specific Technologies

Several specific technologies have been identified as fundamental to ITT's long range programming goals of tenfold productivity increase and zero-defect programs. Three examples are rigorous methods, concurrent languages, and knowledge-based systems.

Rigorous methods. A primary requirement is for more rigor in system specification and development. In particular, rigor means mathematical, theoretical, and formally oriented methods of describing system lifecycles, defining architectural specifications of systems, and characterizing target applications. These methods exist in primitive form: ITT is developing computer-based techniques for their integration and automation.

Concurrent languages. The next generation, highly concurrent architectures (e.g. ITT's System 12[2]) do not have entirely suitable programming languages, since the currently available languages (e.g. CHILL) are best suited to programming single processor, conventional, sequentially oriented computers and, with some extensions, tightly coupled, three to five processor computers. New languages that are compatible with concurrent system architecture are being investigated.

Knowledge-based systems. These are practical applications of research currently under way in the field of artificial intelligence. The large investment by the Japanese in this area is likely to make it an important technology for ITT. Such systems are currently being used on a very small scale by a few industrial companies. The question remains whether these approaches can be practically applied to large-scale problems on a broader basis.

Conclusions

Programming research is a source of innovation and new ideas; however, research has an equally important responsibility to translate these ideas into tools and methods of practical utility to programming practice. ITT's ambitious long term programming goals, a tenfold increase in programmer productivity and zero-defect programs, will be attained as a result of its research programmes in the six "niche" areas. This research will provide the practical applications necessary to assure ITT a continuing strong position in the programming field.

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J. D. Grimes
Chairman, Programming KTSG
ITT Programming Technology Center,
Stratford, Connecticut, USA

Materials: the Key to Technology

Materials technology can be considered the basis for most scientific advances, including VLSI and fiber optics. Thus it will continue to be vital to most advanced technologies up to and beyond the end of the century. New techniques already under investigation will have profound effects on materials characteristics such as wear and thermal stress failure.

Introduction

New materials have played a major role in the rapid growth stage of every major civilization, nation, and industry. References to the Stone Age, the Bronze Age, and the Iron Age illustrate the importance of these materials to survival and progress in those times. Later, the Age of Exploration had as a major incentive the discovery of new sources for gold, minerals, and other materials needed by an expanding society. More recently the industrial revolution required vast supplies of steel, timber, oil, and coal for manufacturing and the growing transportation industries.

Over the past 150 years, the processing and manufacture of industrial materials have undergone a revolution with "materials art" giving way to materials science through which we can understand, control, and utilize the behavior of many important materials. This has stimulated further technological breakthroughs such as nuclear power, the transistor, and optical fiber transmission – in each case laying the foundation for a multibillion dollar worldwide industry.

Automatic machining of ceramic using an Nd/YAG laser.

Materials technology has historically been an important element in the broad manufacturing base of ITT, and will continue as such in the future. Materials research and development provides support and opportunities for ITT's telecommunication, industrial, and automotive products. Several specific areas, however, have a particular impact on major product areas and the present Materials Key Technology Steering Group programme is centered about them.

Within each of these product/technology niches, certain specific technologies have been selected for advanced research and development, including:

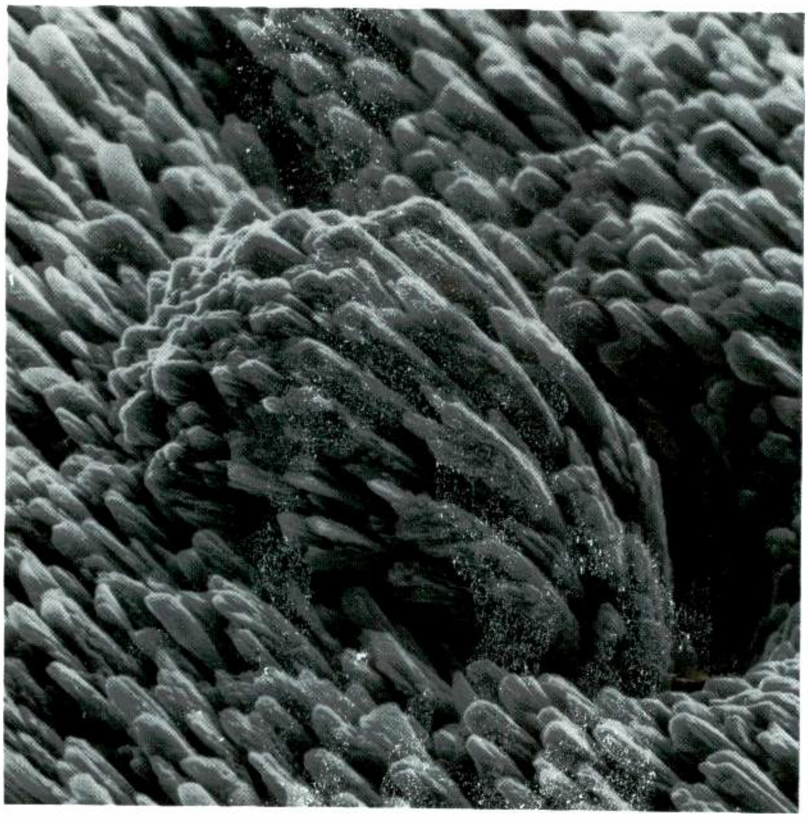
- Improvement of materials surfaces by advanced processing techniques such as ion implantation, laser treatment, and plasma coating.
- Studies of the morphology and rheology of polymers as they relate to performance under high electrical and thermal stress.
- Research on amorphous metal materials to establish optimum compositions and performance criteria for sensors and protective coatings.
- Development of novel piezoelectric ceramics and composites for future speech and graphic terminal applications.
- Research on advanced processing of silicon materials for industrial sensors and related component applications.

These are but a sample of ITT's total effort in materials since the bulk of the activity is being done on dedicated projects by the manufacturing units. It is also only a small start on the materials science and technology effort which will be required to meet the needs of tomorrow's telecommunication products. What role will materials science play in the development of these products between now and the end of this century, and what can we expect of this technology as we move further into the "silicon age"?

Electronic Materials and Processes

Since the discovery of the transistor in 1948, and the birth of the semiconductor industry, an extraordinary emphasis has been placed on developing new processes and analytical techniques related to the preparation and processing of ultra-pure, precisely controlled, or modified semiconductor compounds. This work, which was primarily concentrated on germanium and then silicon, has been broadened to include a wide range of dielectric and conductor materials used in integrated circuit fabrication and packaging. These techniques enable the purity and doping levels within materials to be controlled to parts-per-billion and have provided new insights into solid state behavior.

Controlled morphology vapor-deposited aluminum foil (magnification ×1000).



Raw Materials

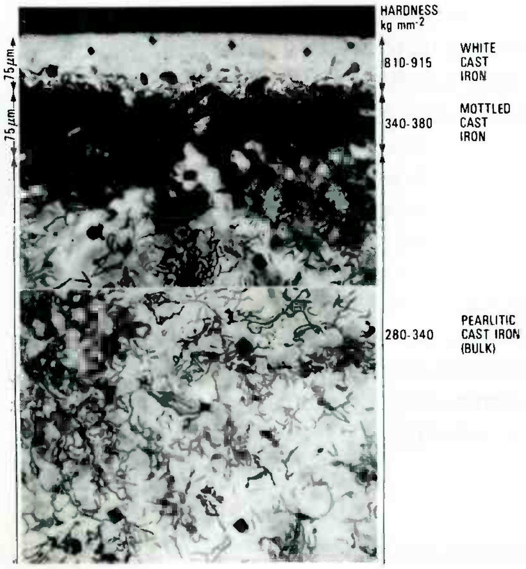
The successful development of VLSI depends on the availability of a consistent supply of high quality, essentially defect free silicon and gallium arsenide wafers. As the industry moved from the 1 inch (25 mm) silicon wafer size of the early 1960s to today's 6 inch (150 mm) wafers, the rate of change was paced primarily by the ability to grow reproducible high-purity defect-free single-crystal silicon ingots. Continued development and improvement of the basic Czochralski crystal-growing equipment has made today's VLSI-quality wafers possible.

For the future it is probably not so important that 8 inch (200 mm) silicon wafers be available. More important, as circuit geometries approach the 1 μm level, is raw material quality. A major challenge to materials suppliers will be to consistently provide wafers with better than one defect per square centimeter at a reasonable cost and availability.

New techniques for producing ultra-pure metal, glass, and ceramic powders of controlled size, shape, and chemical composition have made it possible to develop optimum physical and electrical properties in dielectric materials used in the manufacture of components and the packaging and assembly of semiconductors. Advanced powder preparation methods such as chemical vapor deposition, laser enhanced chemical processing, and plasma techniques, provide new tools for the synthesis of previously unavailable industrial raw materials. As an example, unique fluidized-bed coating processes have provided novel raw materials for manufacturing solid-electrolytic capacitors.

Advanced Materials Manufacturing

The materials processing industry is one which has historically lent itself to automation. Semiconductor manufacture has become capital intensive to the extent that most basic processes, such as diffusion, etching, and photolithography, are now fully automated with microcomputers controlling each stage of the process. Advanced processes such as ion implantation, molecular beam epitaxy, and plasma etching offer new techniques for altering material properties. This capability for precise control of new and powerful processing tools offers excellent opportunities for the future since it provides the necessary tools for selectively tailoring the properties of industrial materials.



Microstructure of a cast iron disk after laser transformation hardening.

Ion implantation, for example, is widely used in semiconductor wafer processing for precisely injecting dopant ions into silicon at the correct location with the proper concentration. This same basic technique can be used to alter the surface characteristics of materials, making it conceivable that future electromechanical components and materials will have performance and reliability levels never before achieved. Problems such as contact wear, loss of hermeticity, and thermal stress failure may be overcome by customizing materials for each application.

Wire and Cable Materials

New materials and processes are constantly being evaluated by ITT as a means of improving the performance and reliability of wires and cables. Present research on dielectric materials has provided new insights into the behavior of insulating polymers under adverse conditions of moisture, high-voltage, and mechanical stress. Relationships are being developed between the internal crystalline structure or morphology of the polymer and the material's sensitivity to these external factors.

Optical fiber cables place new performance requirements on cable materials since the electro-optic, thermal, and mechanical characteristics of the cladding material can strongly affect transmission performance. The need will continue for new precisely tailored claddings with correct optical behavior, thermal expansion, impermeability, and tensile strength, along with processes to apply them in a cost effective and reliable manner. It is therefore imperative that the state of the art in these materials be maintained both in the laboratory and the factory.

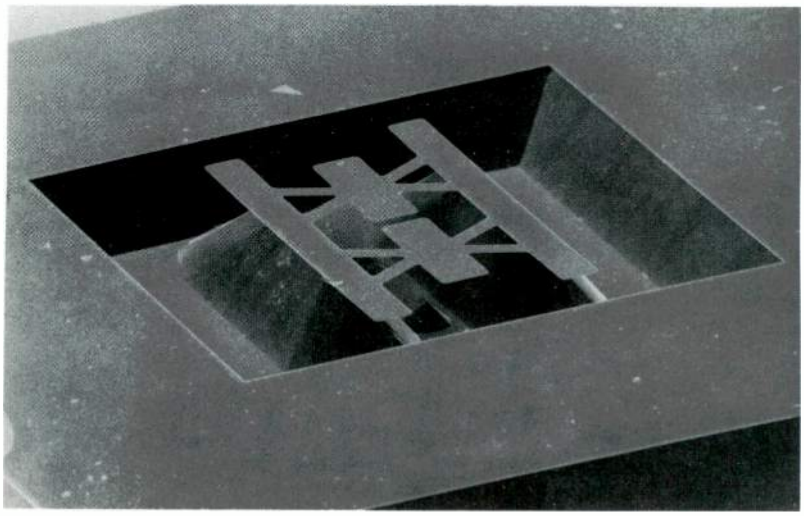
Metal Forming Processes

Within ITT, metal forming represents a major technological investment. Controlled material composition and microstructure are critical in the forming of so-called amorphous metals or metal glasses. High speed solidification of these unique alloys, which are of metallic composition, can make them appear glassy or noncrystalline in structure. They demonstrate unusual properties of corrosion resistance and, in some cases, highly sensitive magnetic characteristics which provide a basis for new sensing devices. As an example, coatings of such a material on the surface of an optical fiber produce magnetostrictive effects that can be used to develop a sensor that will detect extremely low magnetic fields.

Engineering Materials

Molded plastics continue to be important for a myriad of product applications ranging from telephone subscriber sets to automobile bumpers. New structural materials using advanced high-modulus fibers, such as Kevlar, carbon, or boron nitride, may find widespread industrial use, including telecommunication and electronic equipment racks, particularly where ruggedness and mobility are required.

The use of liquid-polymer molding techniques is increasing rapidly, and ITT Cannon has recently entered production with liquid silicone molding of military multipin connectors. Work being conducted in ITT laboratories on elastomers will provide new flexible and repairable insulation systems for interconnections, film circuits, and component packaging. Of particular interest are newer conductive elastomer materials which provide previously unattainable performance. For example, many of today's terminal keyboards and telephone keypads utilize these unique materials for quiet, bounce-free keyswitch contacts.



Novel etched silicon pressure transducer (magnification × 30).

Research and development on ceramics has led to a number of new material systems. Studies at the SEL Research Center, for example, have led to "light-valve" ceramics using barium lanthanum titanium niobate which have been demonstrated in a new high-speed noncontact printer.

The Future

Dramatic breakthroughs in materials research and development occur rarely, and most of the materials used in telecommunication systems at the end of this century probably exist today in one form or another. Our knowledge of materials science and advanced processing technology is, however, increasing at a rapid pace, allowing us to modify and improve materials to achieve new levels of performance and reliability.

In theory one could forecast the development of a "zero attenuation optical fiber resulting from precise control and distribution of the refractive index of glass or other optical material. Perhaps the optical fiber of tomorrow may be a precisely grown single crystal of a complex halide compound.

The role of diamond in semiconductor device technology could change considerably if new processing techniques make it possible to tailor its electrical properties.

Tomorrow's materials processing technology may allow us to build "three-dimensional" VLSI chips layer by layer, leading to order-of-magnitude increases in system speed and performance.

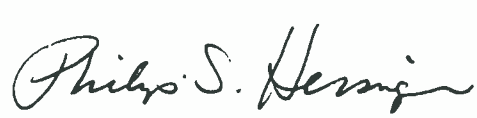
If our knowledge of materials could enable us to achieve room temperature superconductivity, then an entire new generation of materials and components would evolve which would revolutionize electronic systems design.

Perhaps the most profound change will result from our combined knowledge of the biological functions of the human brain and our ability to use new and unique materials and process technology to duplicate those functions for the processing and communication of knowledge and information.

Conclusions

The scope of ITT's interest in materials science is very broad. Because of the Corporation's commitment to telecommunication, materials performing electronic functions either in active devices or as conductors or dielectrics will have an immediate impact on future system performance and reliability. Structural materials will always be a key part of equipment cost and integrity, while coatings and protective finishes will be needed for various environments.

Materials research and development has always progressed slowly, largely due to the need for extensive experimentation, testing, and applications evaluation. It is not unusual for ten years to elapse between the conceptual phase and the commercial introduction of a new material. The ITT key technology programme on materials is based on utilizing both internal laboratory resources and the external resources available at universities, through suppliers, or by license, as appropriate. Close interaction between the ITT research centers and manufacturing houses will ensure that the latest and best materials technology is available when it is needed.



P. S. Hessinger
Chairman, Materials KTSG
Director, Applied Technology,
ITT Headquarters, New York, USA

VLSI: the Challenge of One Million Transistors

Functional complexity and computing power will continue to grow as feature sizes in VLSI circuits are reduced. Major results will be achieved through the use of more advanced system architectures and new algorithms capable of utilizing the millions of transistors that will shortly be defined on a single chip of silicon.

Introduction

Since the invention of the transistor 35 years ago, advances in semiconductor technology have resulted in an increase of six orders of magnitude in the functional complexity of chips. Such recent accomplishments as single chip 32-bit microcomputers and 1 Mbit memories are but examples of the "silicon system" building blocks with which advanced electronic systems are being designed. Future equipment and systems will be dramatically more capable as a result of the powerful and inexpensive computing resources provided by VLSI (very large scale integration).

Figure 1
Trends in MOS technology.

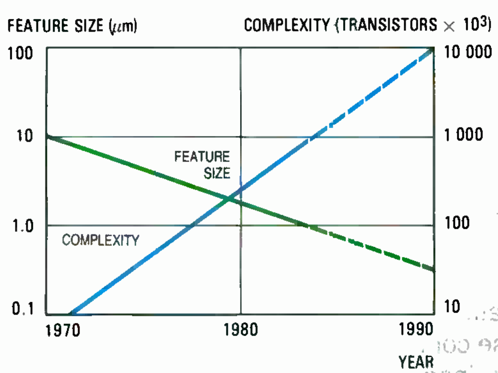
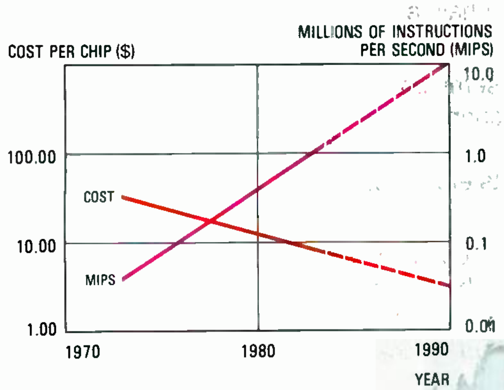


Figure 2
Trends in microcomputer chip technology.



Technology Trends

Advances in semiconductor technology can be measured in terms of three parameters. The first is transistor feature size. Over the past 10 years, the basic dimensions used in transistor design have decreased from 10 μm to 1 μm (Figure 1); a similar reduction will occur during the next decade.

Second is the functional complexitiy of the chip. Continuous refinements in process technology, coupled with innovative circuit design, have resulted in a thousandfold increase in the number of transistors on a chip; the one million transistor chip is already in the laboratory stage of development.

The third parameter is computing power. The increase in functional complexity stimulated the "silicon system" thinking that led in 1971 to the first microprocessor chip, a 4-bit central processing unit. Currently the state of the art in such building blocks is exemplified by 32-bit microcomputers that provide processing power of the order of one MIPS (million instructions per second) – 20 times more powerful than the 4-bit chip of 12 years ago (Figure 2).

However, VLSI is not just a numbers game of microns, millions of transistors, and millions of instructions per second. It is also a methodology by which advanced system architectures can be conceived and implemented. These architectures will provide the processing power necessary to enhance system performance, improve fault tolerance, and make systems easier to use. VLSI is expected to have its most significant impact in these areas.

The Challenge

Electronic equipment and the work environment are placing increasingly more demanding requirements on communication and computing. Higher levels of functional complexity are needed for:

- speech synthesis and recognition
- video compression and intelligence extraction
- fault-tolerant architectures
- on-board testing and diagnosis
- computer-aided instruction
- structured databases (knowledge bases).

When such capabilities are to be applied to professional workstations in the context of providing solutions to organizational needs, the following services are required:

- multiperson, multimedia communication
- knowledge processing
- computing and analysis
- activity management.

Each of these tasks is computationally intensive, requiring real-time response, on-line assistance, structured information flow, and communication facilities. Figure 3 shows quantitative measures for the ranges of computational requirements for speech and image processing. Real-time, user-independent speech recognition may require 1000 MIPS; advanced tactical radar systems will soon require 20000 to 30000 MIPS. To make this level of performance economically attractive, it will be necessary to improve the performance of today's super computers by 10 to 100 times, with attendant cost and physical size reductions.

Paths to Increased Performance

Certainly VLSI will continue to provide improved performance as a result of the push for submicron feature sizes in silicon and the maturation of gallium arsenide technology. However, the improvement in computing power by several orders of magnitude will require more than just advances in VLSI. Two additional factors will bring about substantial breakthroughs in processing power (Figure 4):

Architecture. As mentioned previously, advanced system architectures will make it possible to exploit high functional complexity at the micron and submicron levels. Such architectures as associative arrays, systolic arrays, and tree structures could outperform the current generation of Von Neumann machines by a factor of 50 to 100, using the same level of VLSI technology. Futhermore, the newer architectures are uniquely suited to the

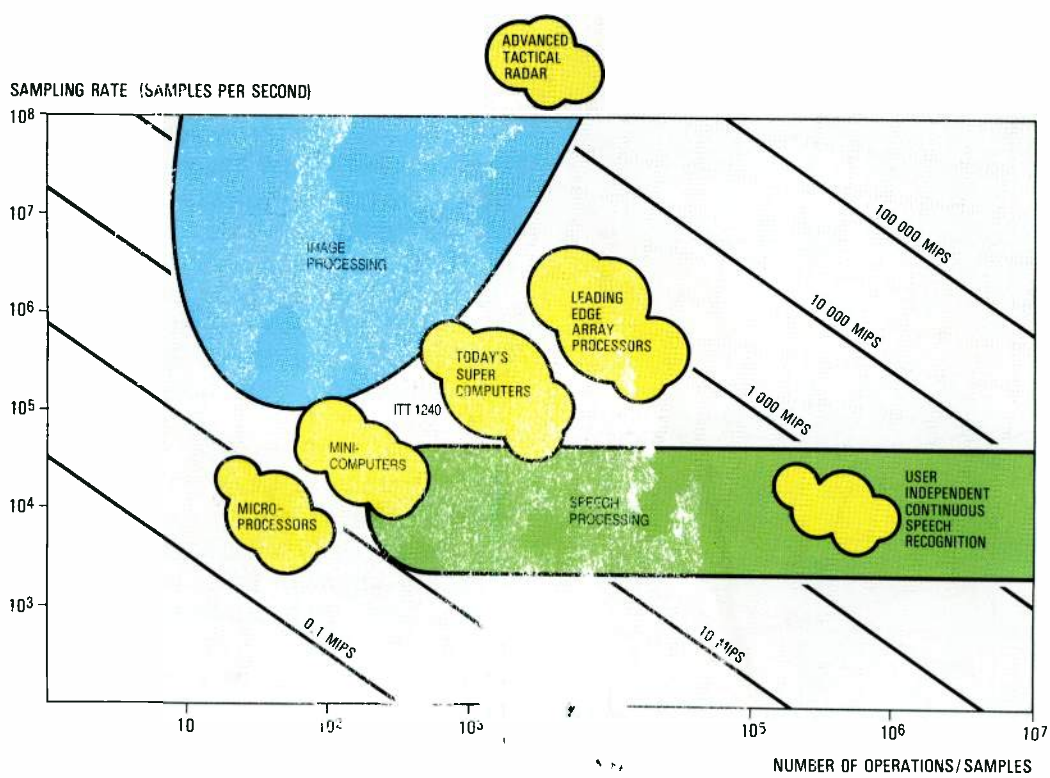


Figure 3
Trends in information processing requirements.

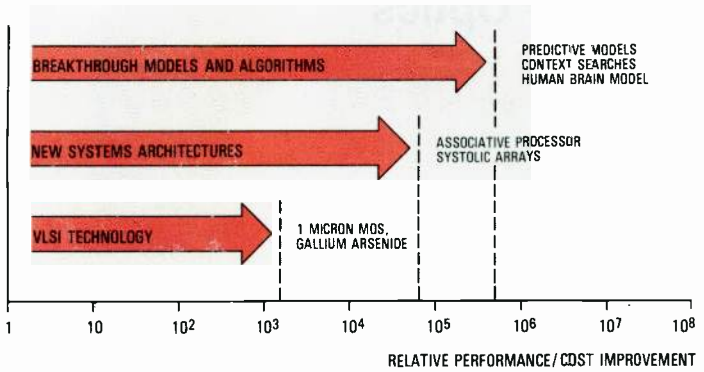


Figure 4
Approaches to increased processing power.

computationally intensive tasks of pattern recognition and signal processing, and provide built-in fault tolerance.

Algorithms. The new architectures will make possible substantial studies into concurrent algorithms, statistical modeling, and conceptual approaches that begin to approach the processing mechanisms of the human brain. The algorithms in use today were optimized for the sequential Von Neumann architecture. They could execute more rapidly on highly parallel, data-flow-oriented architectures, but would be even more efficient and powerful if they were reconceived and optimized for the parallelism that is inherent in these new machines.

The task of dealing with the large numbers involved in speech and image processing may be better approached statistically. The use of statistical mathematics to create models for speech and vision may herald a breakthrough in real-time pattern recognition tasks.

Finally, architectures represented by associative array processors and languages represented by the LISP (list processor) family are beginning to direct computer thinking processes towards pattern matching based on pattern content and interrelationships – so-called "right half brain" processing. When these architectures are coupled with statistical modeling and probability theory, it will be possible to construct computers that can learn, base decisions on incomplete information, and improve their performance with experience.

Definitions

Array processor: a repetitive arrangement of single-bit or multiple-bit processors, working in parallel executing single instructions on multiple data items.

Associative processor: an array processor that allows the contents of multiple data items to be compared simultaneously.

Systolic processor: an arrangement of processor elements that asynchronously execute a fixed set of instructions as data flows through the system.

Tree structure: an arrangement of processors interconnected to specific nearest neighbors (similar to tree branches) and executing instructions based on the content of the data entering each "tree branch" node.

Conclusions

VLSI represents the tip of the iceberg with respect to the evolution of electronic systems, providing the means to put millions of transistors on a single chip of silicon. The challenge is to maximize this capability through creative approaches to the design of building blocks for speech, image, and knowledge processing. Silicon systems (rather than systems with silicon), coupled with advanced architectures, models, and algorithms, provide a powerful approach to the ultimate exploitation of semiconductor technology.

B. H. Soloway
Chairman, VLSI KTSG
Director, Systems Research Division
ITT Advanced Technology Center,
Shelton, Connecticut, USA

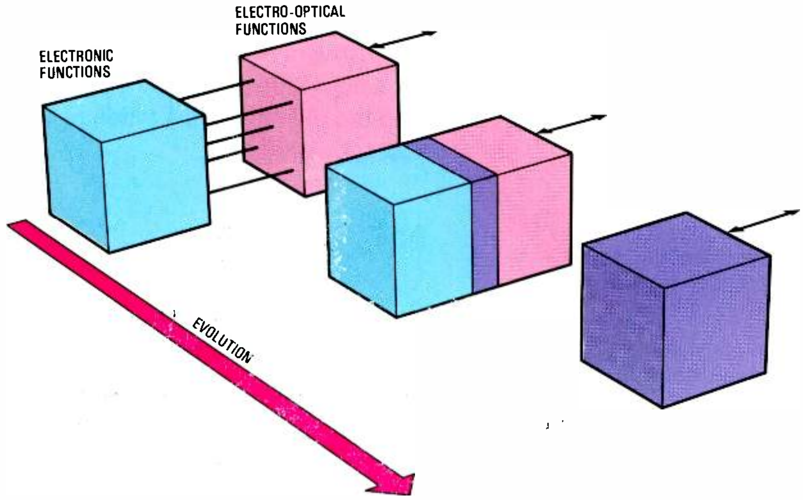
Rapid Evolution of Fiber Optics

Over the next decade – or less – the distance-bandwidth product of optical fibers will dramatically increase by a factor of something like 40 times as a result of the introduction of coherent technology. This will, in turn, speed up the introduction of integrated optoelectronic circuits.

Introduction

Within the next five to ten years, low-loss, single mode optical fiber waveguides will be able to carry digital multichannel video-bandwidth signals at transmission rates in excess of 6 Gbit s^{-1} over unrepeatered distances of 100 km or more – 40 times the distance-bandwidth product of today's optical fiber, and 200 times that of copper wire. This improved performance will be brought about by technological advances in three principal areas: coherent technology, integrated optoelectronics, and materials processing.

Figure 1
Evolution of the integration of optical and electronic transmission system components.



Coherent Technology

In even the most advanced of today's optical transmission systems, the light source generates incoherent bursts of energy. Coherent technology will make optical light sources equivalent to radio frequency sources; that is, they will output waves with a high degree of spectral and temporal coherence.

Coherent technology will make it possible to use signal processing techniques at present applied to radio frequency carriers, in optical fiber systems, thereby improving the flexibility and versatility of signal handling. For example, it will be possible to design systems for more effective signal manipulation, making tradeoffs between signaling speed and spatial assignment. A given traffic volume can be carried in a variety of ways in terms of signal speed, number of carrier wavelengths, and number of optical fibers. Phase information (e.g. the relative phase difference of carrier wave and reference beam) also increases detection sensitivity through the use of interferometric techniques.

On the debit side, coherence of light signals produces some undesirable side effects. One of these, modal noise, has already been encountered in transmission systems that are nominally incoherent. Also, coherence reinforces the effects of nonlinearity to produce significant signal degradation, particularly in single mode transmission systems. It will be necessary to gain a thorough understanding of these phenomena before very high capacity systems with long repeater spacings can be achieved.

The theoretical advantages of coherent technology will not be realized until steps are taken to modify the properties of components (e.g. stabilize laser emission wavelength, intentionally introduce a certain amount of incoherence, or limit the power or light sources), and to control such undesirable side effects as nonlinearity-induced noise and interfering signals (e.g. modal noise).

Integrated Optoelectronics

Integrated optoelectronics is the combination of optical and electronic components in stable, high-performance subsystems that initially will include both electronic circuits (for signal generation, modulation, amplification, detection, switching, and filtering) and optical components (light sources and detectors). Acoustic components may be used for coupling.

The three-phase evolutionary process is illustrated in Figure 1. The first phase represents early optical fiber systems with no integration; the second phase is the current state of the art with some integration, while the third phase is the fully integrated structure. It will be possible to construct integrated structures on a single-material substrate of a ternary or quaternary (i.e. with three or four components) semiconductor, so that the fabrication requirements of electronic and optical devices can be met by a single material rather than two or more.

Integrated structures will employ either discrete switches or signal distribution techniques. That is, one line can be coupled to another by a switch which handles individual bits on a time basis and consumes a certain amount of power. Alternatively, bits carried by coherent light waves can flow from one line to another using a signal distribution technique that utilizes both space and time sequencing and possibly consumes less power.

The primary advantage of integration will be to ease the interconnection problems that occur during electronic/optical and optical/electronic signal conversion. Also, a stable structure is the key to achieving circuits that can handle coherent optical waves in a small, densely packed, and highly versatile configuration.

This technology will extend the upper limit on the frequencies that can be carried on an electronic circuit; sub-nanosecond pulses will be handled with ease.

Materials Processing

Materials processing technologies for electronic components are improving rapidly as a result of improved tools and techniques (e.g. sub-picosecond pulse probes, molecular beam epitaxy, and metallic-organic vapor phase epitaxy). Thus electronic and optoelectronic devices will be able to work at higher frequencies while maintaining the necessary gain and low noise characteristics. The operating speed of these devices – up to 10 GHz, about an order of magnitude greater than present performance – will be exploited in

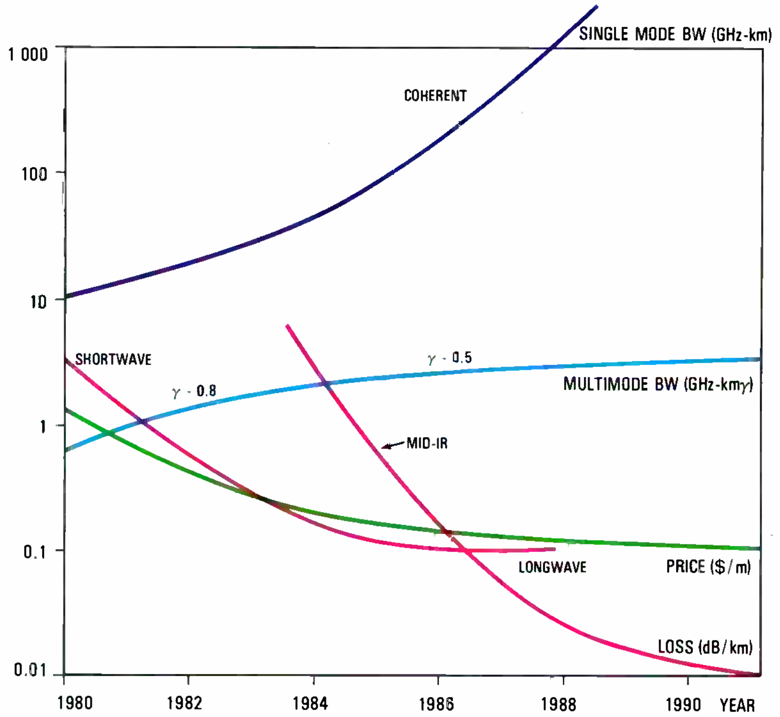
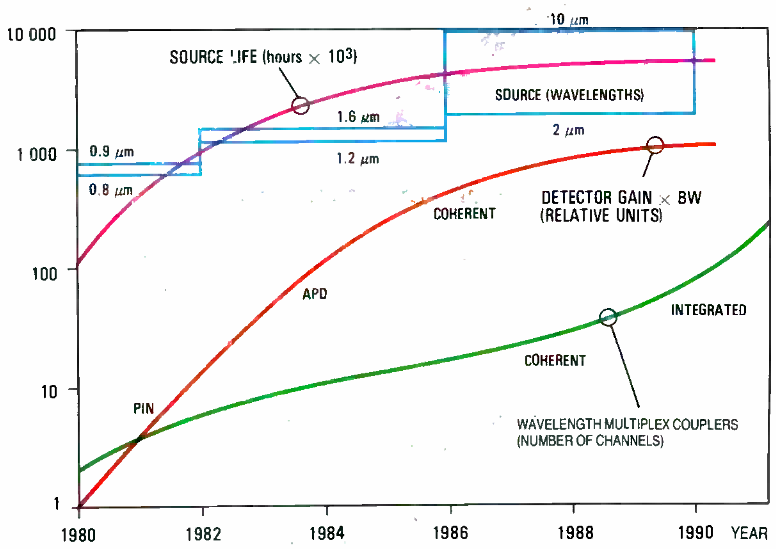


Figure 2
Evolution of optical fiber performance to the end of the decade.
BW - bandwidth
IR - infrared.

telecommunication equipment capable of handling the ever growing volumes of traffic that are an inescapable consequence of the continuously increasing speed of data processing; this process is self-reinforcing.

Expected performance parameters for optical fiber, light sources, light detectors, and wavelength multiplexers are shown in Figures 2 and 3. In interpreting these figures it is important to note that the performance figures represent possible achievements in each technology sector; there is no intention to imply that these performance levels will be achieved simultaneously, or in any particular combination. For example, the 2 to 10 μm lasers required for long

Figure 3
Evolution of performance of optical transmission system components.



distance, repeaterless applications are likely to require cooling, and 0.01 dB km^{-1} fiber loss will be attainable only at some wavelength in the 2 to 10 μm range. However, the need for cooling need not pose serious problems – portable coolers capable of liquid-helium temperatures are already available. Thus it is quite valid to conclude from these performance/parameter projections that powerful new transmission systems based on these improvements can be realized.

Declining costs of optical fiber and associated components will make it possible to offer broadband telecommunication services in the subscriber area. However, cost reduction alone will not bring about widespread demand for a broadband local area network. The impetus will come instead from the need to connect home computers interactively with centrally located databases, the contents of which will include full motion video information. Although it is difficult to envision such a need becoming urgent, it is easy to see that it has a place in our continuing attempt to extend our physical senses. Thus there is no doubt that progress in fiber optics will accelerate the enhancement of services offered in the subscriber area.

Conclusions

Fiber optics will continue to be the basis for expansion of the telecommunication network well into the 21st century, making it possible to transmit ever greater quantities of information over longer and longer distances without the need for repeaters. Based on foreseeable developments in coherent technology, integrated optoelectronics, and material processing, it is possible to predict with confidence that fiber optics applications will continue to proliferate and technology will improve for the benefit of mankind.

C. K. Kao
Chairman, Fiber Optics KTSG
ITT Executive Scientist
ITT Headquarters, New York, USA

The New Biotechnology

Present development work on tissue culture and gene transfer will improve the characteristics of many plants and cereal crops. At some not too distant date, nutritional value, disease resistance, cold hardiness, and drought tolerance will all be improved. These technology gains will help alleviate the hunger that is endemic in many countries today.

Introduction

Since 1950, great strides have been made in our understanding of animal, human, and plant life processes. This broadening biological revolution has spawned a new branch of biology, popularly termed biotechnology. Development in biotechnology has been so rapid that few outside the field are aware of the research achievements within it and their potential impact.

In recent years ITT has taken an active interest in plant life aspects of biotechnology. The agricultural market for biotechnology products is now projected to be between $50 and $100 billion by the turn of the century. Dedicated scientists in ITT, in leading universities, and in many other research centers will be discovering, one by

A marigold plantlet growing in a tissue culture test tube system (inset) can be nurtured and propagated to yield a field of marigolds.

one, the steps necessary to uncover the remaining secrets of plant life.

Disciplines of Plant Biotechnology

Research in plant sciences can be classified into four closely interrelated disciplines: propagation, diversification, selection, and gene transfer. These will affect three ITT business areas: forest products (ITT Rayonier); food products (ITT Continental Baking); and seed and fertilizer products (ITT Scott/Burpee).

Propagation is the application of biotechnology to methods of multiplying plants with high fidelity. The primary method used is tissue culture – the process of sustaining living tissue in a test tube. Tissue culture replications can be performed more rapidly and economically than by traditional plant breeding methods utilizing seeds or cuttings.

For increased genetic diversity, the plant breeder's quest can be facilitated using another biotechnology technique – diversification (Figure 1). Sexually incompatible species can be crossed to yield progeny that possess desired traits from both parents. In this way, valued traits, which may only be found in diverse plant types, can be united in a single plant. Entirely new plants can also be created by bringing together the chromosomes from two different plant species; success with cereal grains has led to increased experimentation in this area.

In the long history of plant evolution, nature has selected plants for their optimal adaptation to an environment. Unfortunately nature's selection process requires thousands of years. In contrast, selection using the tissue culture technique can screen millions of plant cells in a few square feet and with a high probability of obtaining the desired results.

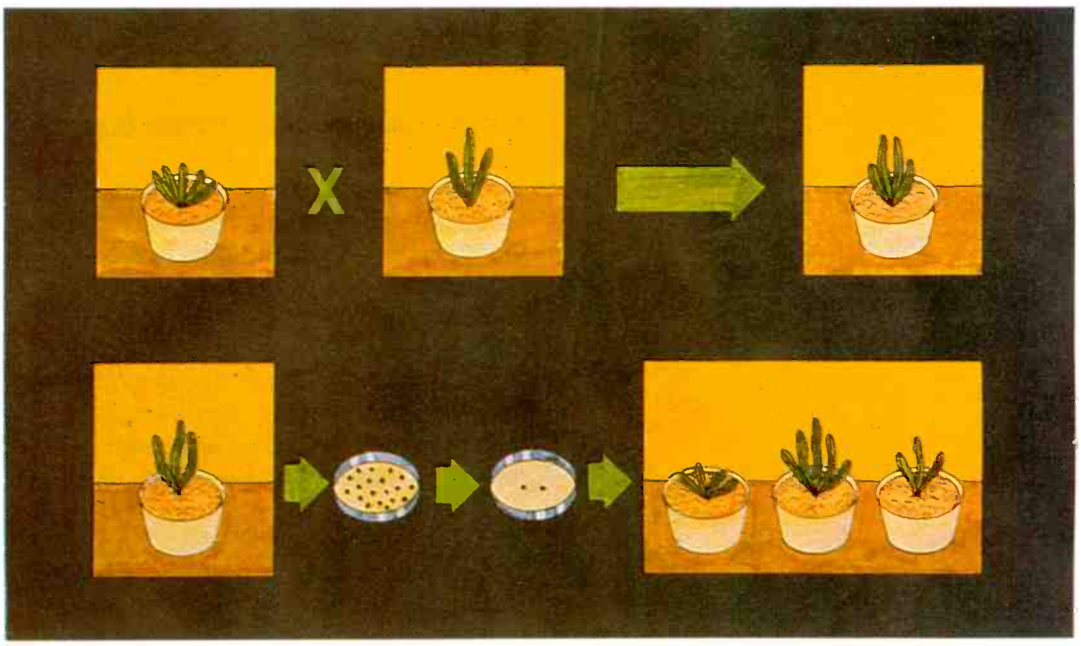


Figure 1
Increased genetic diversity chart.
The top illustrates traditional sexual propagation of plants, while the bottom shows how tissue culture can be used to increase genetic diversity, yielding progeny with the desired traits.

The most popular of the new biological technologies – gene transfer – involves identification of the specific gene coding for certain desirable traits. This step is followed by the transfer of an identified gene to a different plant, which, when the gene is expressed, imparts the new traits to the host. This discipline is most often called genetic engineering.

Although intensive research is being conducted in all four of these biotechnology disciplines, some areas of research will be finished before others as a result of the stepwise and deliberate nature of biological processes. For example, even though considerable limitations remain to be overcome for cereal crops, such as corn and wheat, propagation techniques are already being used extensively in some horticultural applications. Most African Violets and Boston Ferns sold commercially are being propagated by tissue culture. Impressive progress is also being made in diversification and selection procedures. Of the four disciplines, gene transfer is likely to be the last biotechnology method to become fully commercial.

The new biotechnological techniques have the potential to revolutionize agriculture, as well as to make remarkable improvements in food crop and forest production. Within 10 to 20 years, most of the important economic food, flower, grass, and forest crops will be propagated from tissue culture. This will permit increased genetic diversity and the selection of such desirable plant characteristics as disease resistance, cold hardiness, and salt, herbicide, and drought tolerance. In addition, the nutritional quality, protein and oil content, and processing characteristics of food crops can be improved. The net result will be increased crop productivity in both bulk and caloric yield.

It is possible that the cost of food may decrease with greatly increased productivity, and that there will be a decreased need for the whole spectrum of herbicides, pesticides, and fungicides. Land areas not suitable for agriculture may ultimately produce improved forest yields, which would make more wood available for energy as well as chemical and food feedstocks.

Horticulture

In horticulture the biotechnological emphasis is somewhat different from that in agriculture. Rapid and economical propagation of unique plant varieties by biotechnological techniques will become increasingly important, as presaged by the successful propagation of the African Violet and Boston Fern through tissue culture. In the next 5 to 15 years, most research will focus on propagation. A second step will be the introduction of diversity to obtain improved or unique plant varieties. After these methods have become established, selection techniques will be utilized to develop hardier plants with special emphasis on disease, salt, herbicide, and cold tolerance. Over a 15 to 25 year period, gene transfer will become increasingly important as a technique to improve atmospheric and soil nitrogen fixation. As the economic potential of horticultural crops is less than that of agricultural crops, horticultural applications of biotechnology may lag behind similar advances in agriculture.

Using traditional plant breeding methods, the progeny of a sexual cross exhibits a combination of parental traits. Using biotechnology, genetic diversity can be induced in the progeny. The grass on the left was raised using tissue culture to achieve the desired turf characteristics of compact, uniform growth. The grass on the right, the parent which was bred by standard techniques, does not exhibit these characteristics.

Photosynthesis and Nitrogen Fixation

Around the turn of the 21st century, important developments are expected in photosynthesis and nitrogen fixation. Improved photosynthetic conversion of light energy to chemical energy (now between 1 to 3%) would greatly improve crop productivity. Plants could be placed more closely together. Yields would increase and biomass as an energy source would be more practical.

The capability of converting atmospheric nitrogen into usable plant nitrogen is believed feasible for grain crops. This would reduce dependency on synthetic nitrogen fertilizers which use natural gas as an ingredient in their manufacture. In those areas of the world where synthetic fertilizers are unavailable, plants with the capability of fixing nitrogen from the atmosphere would greatly improve crop yields and help alleviate food shortages. Many observers feel that the development of grain crops with the capability of fixing their own nitrogen, plus improvements in photosynthetic efficiency, may prove to be the greatest achievements of the new plant biotechnology revolution.

Single Cell Protein

The development of an economically competitive single cell protein source (technically not an agricultural product) may have a significant impact on agriculture. Produced in fermenters, single cell protein is a nutritional food source obtained from micro-organisms or plant cells. Micro-organisms have long been used to produce antibiotics, following the initial success of penicillin. An even older fermentation process is the use of yeasts to produce liquors, wines, and beer. If the process is feasible, single cell protein could compete with soyabean meal and grasses as animal feed.

Conclusions

The new plant biotechnology is a growth industry. There is no question as to the eventual commercialization of all four of its scientific subdivisions. The question is not whether but when. Market entry requires a firm commitment to future growth with a significant capital investment, with short term gains being sacrificed for potentially larger and longer term rewards.

The foundation and framework of ITT's participation in these new industries are now being put in place. The ITT associates O. M. Scott and Sons and W. Atlee Burpee have active research programmes underway on turf grasses, vegetables, and ornamental flowers. These programs provide ITT with an initial entry into a market segment with little industrial biotechnology competition. Established Scott and Burpee marketing outlets provide a competitive advantage over research oriented firms without such marketing expertise and coverage.

Acknowledgment

The author would like to thank Dr John Long and Dr Philip Trinity of ITT Scott/Burpee for their considerable help in preparing this article.

J. Paschall
Chairman, Biotechnology KTSG
Director, Energy Technology
ITT Headquarters, New York, USA

Research as a Foundation for Future Products

An Introduction

Advanced technologies in such fields as VLSI, systems, programming, and optical fibers are the keys to the success of telecommunication products in a changing and increasingly competitive market. ITT's European research laboratories therefore have an even more vital role than in the past, and are adapting to meet the challenges of the future.

Telecommunication and electronics are entering a dynamic and expanding technological era. User demands for new services and higher quality and reliability mean that advanced technologies (and especially microelectronics) are now being applied over a wide range of products. These include the more traditional products such as subsets, transmission and switching equipment, and PABXs,as well as newer end user products like multifunction terminals, data and video services, ISDN, and office systems.

Within this environment ITT is committed to advanced technology products. Around 1.3 billion US dollars are invested annually in research, development, and engineering (RD&E) at 45 centers in 24 countries. Half of this represents locally funded research and development (R&D), with investment in strategic advanced technology in excess of $100 million, or 15% of the worldwide R&D activity. The vast and varied resource of skills and knowledge that has been created within ITT as a consequence of this continuing investment forms the backbone of the Corporation's high technology business.

Advanced technology underpins future telecommunication and electronic systems and products, focusing on systems, intelligent products, programming, materials, VLSI, and fiber optics – six of the key technologies discussed elsewhere in this issue. ITT's affiliated European research centers play a major part in the strategic development and application of technology. Located in Germany (SEL Research Center), Belgium (BTM Advanced Research Center), Spain (SESA Research Center), Italy (FACE Central Laboratory), Norway (STK Research Center), and the United Kingdom (Standard Telecommunication Laboratories), these centers undertake 40% of ITT's worldwide advanced technology R&D. They also enjoy fruitful cooperation with ITT's major research centers in the USA – the Advanced Technology Center at Shelton, Connecticut, and the Programming Technology Center at Stratford, Connecticut.

The European research centers fulfill dual roles as national units serving the local ITT companies and telephone Administrations, and as international units cooperating with each other and with ITT companies throughout the world to ensure that advanced technologies are disseminated to all development and manufacturing houses where they will be used to improve existing products and develop new ones. Thus the centers also act as gateways for technology into their own countries.

As telecommunication is ITT's major product area, the laboratories naturally place emphasis on switching and transmission technologies, including fiber optics, advanced telecommunication systems, digital technology, and programming. In this area, the laboratories have played a crucial role in developing the ITT 1240 Digital Exchange.

To avoid duplication of effort, and because some research disciplines require a sizable minimum group to be effective, several laboratories have areas of specialization. The SESA Research Center in Madrid, for example, has a worldwide reputation for traffic theory and application, and for computer network planning tools. The BTM Advanced Research Center, on the other hand, has a strong VLSI capability, while the SEL Research Center in Stuttgart has considerable expertise in fiber optics and ceramics. STL in Harlow undertakes very advanced materials research, as well

Research into advanced technologies is essential if future products are to be successful. ITT's research centers in Europe and the USA are designed to ensure that the Corporation's manufacturing units have access to the latest state of the art in telecommunication technology.

as being a pioneer in the field of optical fibers; they also have a strong systems design group. The FACE Central Laboratory in Pomezia offers experience in ISDN technology.

Advanced technologies being developed within ITT include: fiber optic cable for a transmission rate of 1 Gbit s^{-1}; MOS VLSI with a 1 μm feature size; integrated optoelectronics; and revolutionary system design and simulation tools and methodologies. A crucial element of future integrated services and information systems is highly integrated microelectronics. Today's microprocessors have processing speeds of millions of instructions per second, but future processors using optical or 3-dimensional semiconductor structures will process information at billions of instructions per second. This will provide enormous potential, but will require new design methodologies and tools to master the complexities of such structures and systems.

As the following three articles show, ITT's European laboratories are already developing the technologies that will make this dramatic increase in processing speeds possible. Other technologies will support the evolution of intelligent products, local area networks, speech recognition systems, and flat panel displays to name just a few from a very wide range of developments.

Advanced technologies for the future represent a significant and increasing part of total corporate R&D investment. The following contributions from the directors of three of ITT's European research centers outline the varying roles of each unit during the rapid evolution of telecommunication systems. Each director takes a brief look at the way certain key technologies will evolve, and shows how his research center is itself evolving to meet the challenges of the future.

R. Palmer
Director, Advanced Technology,
ITT Europe Inc, Brussels, Belgium

Telecommunication Research in the 1990s

As the evolution to a future ISDN accelerates, computer programs for planning the networks of the future will have an important role. Starting from the present predominantly analog network, they can ensure that each step towards the future is optimum in terms of services and cost, and that at no stage does a change constrain further evolution.

Introduction

During the current decade, a new technology is emerging which makes digital transmission and switching feasible, and encourages a move from the existing telephone service – still in good health – towards the information delivery systems of the 2000s which will offer a full range of voice and non-voice services via an ISDN. Microelectronics is the key and spur to this evolution, although the large investments required in telecommunication will ensure that each step on the way is carefully assessed.

The Future ISDN

The dramatic rise that is expected in the demand for non-voice services over the next ten years, as illustrated by predictions for the Spanish network (Figure 1), will initially be served by dedicated networks each far smaller than present analog telephone networks. However, this situation will certainly change and a mixed network scenario can be foreseen for 1990.

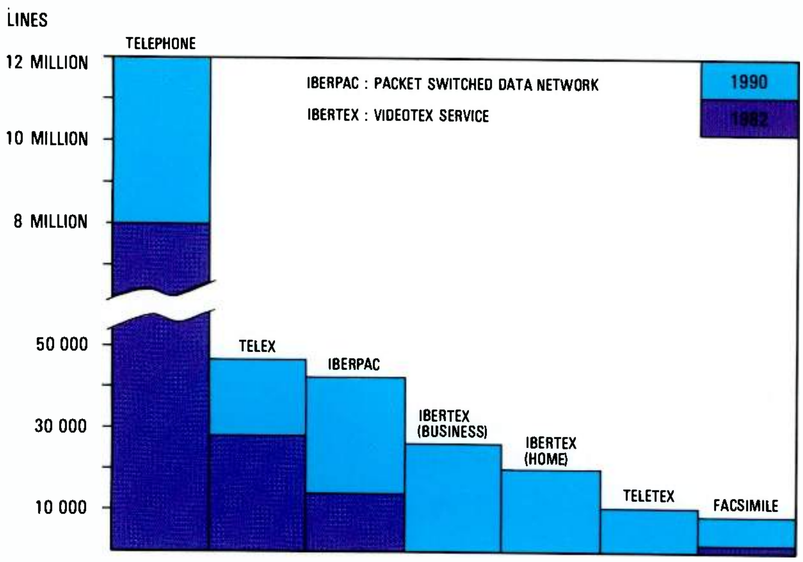
At that time, most telephone subscribers will still be connected to electromechanical exchanges, but increasingly telephone subscribers will be offered enhanced services via digital exchanges, which may be located with or remote from the electromechanical exchange. At the same time, a variety of dedicated private networks utilizing leased circuits at 16, 32, and 64 kbit s^{-1}, will coexist with public data networks to provide different service options.

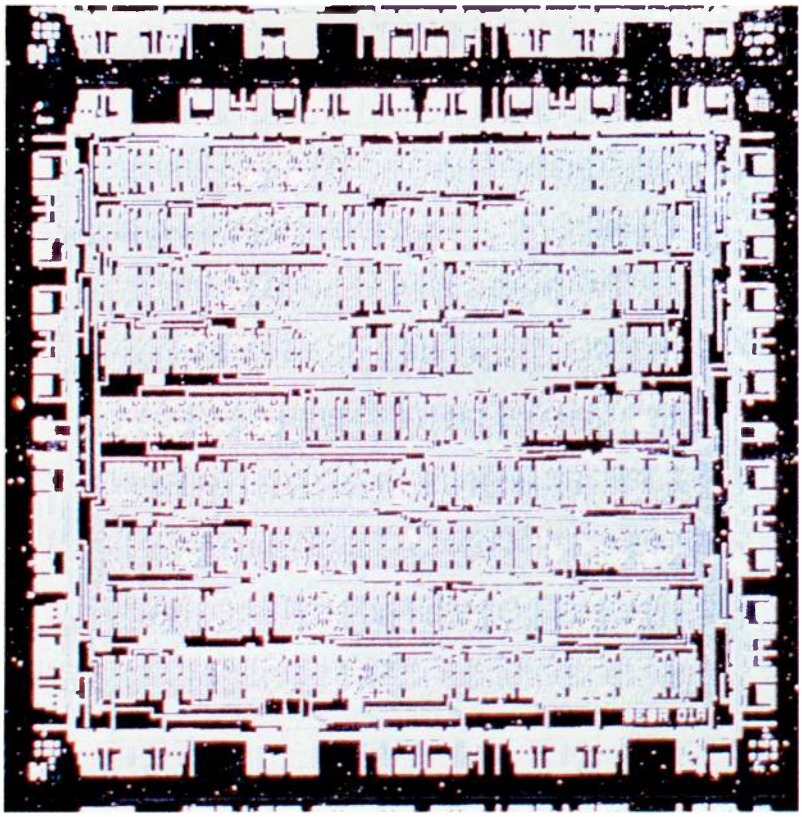
Monomode and multimode optical fiber cables will run in parallel with conventional wire pair and coaxial cables; the coaxial cables may include tubes for both frequency division and time division multiplex transmission.

Subscriber terminals will range from old telex equipment operating at slow speeds on dedicated networks, to electronic teletex stations connected to packet switched data networks within an integrated digital network. The integration of functions in the subscriber loop (now called ISDN) depends on the level of integration in the network, and will be implemented by various available technologies.

During the 1990s, this complex scenario will continue to evolve rapidly as more and more telephone networks "go digital". At this stage, business subscribers in all countries should be able to connect to a digital exchange; the benefits of the ISDN will by then be accessible by most potential subscribers. A high and sustained demand for non-voice services is forecast, enabling Administrations to plan all services adequately and optimize network investments. Of course, in each country network evolution will be determined largely by the particular non-voice services

Figure 1
Anticipated dramatic rise in the demand for non-voice services in the Spanish network over the next decade.





The first Spanish chip designed at SESA RC.

demanded and the constraints of the existing networks, just as it is today.

Changes in Product Lifecycle

An important factor to consider now is the major reduction in the traditionally long lifecycle of telephone equipment (60-year old exchanges are still operating in many countries) as a result of the accelerating evolution in services and the way they are implemented due to advances in technology. On a corporate basis, therefore, ITT and its units worldwide will meet the following commitments:

– Develop, design, and manufacture a range of telecommunication products that economically covers both general and market-specific technical requirements, in each case with equipment that can evolve as technology advances.

– Optimize the development and manufacturing cycles in order to keep abreast of technological evolution, and provide for rapid enhancement or replacement of systems and products.

These considerations lead to a definition of the supporting and leading roles of a telecommunication research laboratory.

Role of Standard Eléctrica Research Center

System Technology
The Standard Eléctrica Research Center is the lead house within ITT in the areas of teletraffic and network planning. In addition it has accumulated expertise in several other areas of advanced technology to support the parent company, Standard Eléctrica. In the area of network planning, between 1986 and 1990 an extensive set of computer network planning aids (developed to dimension and optimize mixed analog and digital networks, fully digital telephone networks, dedicated data networks, and ISDNs) will be used in studies aimed at defining the evolution of public telecommunication networks, and to identify the products and systems required in the decade 1990 to 2000. By 1990 a new set of computer programs for optimization of the design of ISDNs will be in field use. This new set will implement different levels of integration in order to meet the specific requirements of the various approaches to the transition to digital and integrated services networks. Computer aids will continue to be essential tools for the study and evaluation of different network options and for providing rapid answers to support the optimum introduction of new products into existing networks. These tools will be used directly by telephone Administrations as part of their decision-making and planning processes. Over the same period, research and development activities in the field of traffic will focus on simulation models for non-voice services, on modeling queuing networks, and on defining evaluation models for computing the performance of system architectures.

Further refinement of models and techniques designed for networks and systems under development will then take place over the next few years as the integration of voice and non-voice services continues. Models developed during this period for analyzing system architecture tradeoffs will then be applied in ITT system designs of the 1990s.

Programming Technology
Telecommunication systems are real-time systems with a high degree of concurrency and parallelism, in which programming is a key technology. The present programming languages and techniques are not satisfactory to represent, analyze, and design such systems when they become

very complex, as is the case with VLSI technology.

During the 1990s, SESA RC will concentrate efforts in this area on developing languages and techniques supported by graphics and formal methods, and a set of computer tools integrated in a programming environment such as an electronic desk or programmer workstation. This environment will enable designers to detect and correct errors early in the product lifecycle, to analyze the complex situations that can arise in concurrent real-time systems (deadlocks, races, waiting states, etc), and to reuse designs using abstract software components or building blocks. These techniques and tools will enable ITT products to react more quickly to changing user requirements while offering more reliable and cost-effective systems, as viewed by the users.

An example of the SESA RC activity in this area is the Galileo design language which is aimed at establishing unambiguous methods of communication, analysis, and design for real-time systems (Figure 2).

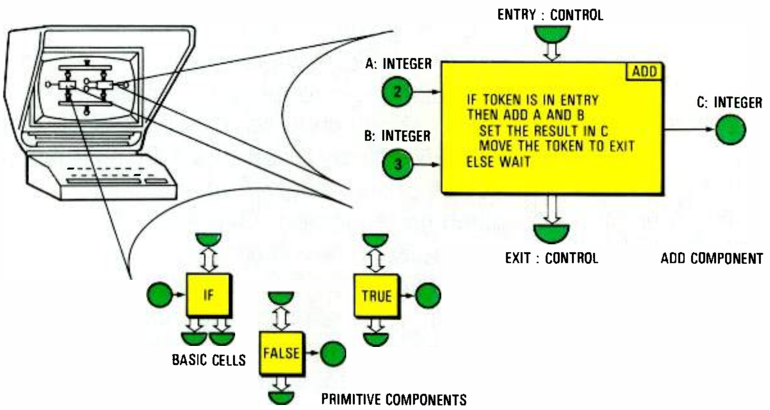


Figure 2
Some basic elements of the Galileo design language which was designed at SESA RC to provide an unambiguous method of communication, analysis, and design for real-time systems.

CAD/CAM Technology

To reduce the design and manufacturing cycles, a significant effort will be maintained in the areas of hardware and software design, and in the digital transfer of design information to manufacturing. Upgrading of tools for LSI and VLSI design, availability of tools for structured design, and procedures for reusing blocks have been and will continue to be priority activities. In parallel, new tools developed for integrated circuit design can be used for more conventional hardware design at circuit and system level, thus enabling designers to reduce development time and enhance reliability, to produce better documentation, and to verify intermediate designs by computer.

Microelectronics

In line with worldwide trends, the increase in custom design LSI circuits is contemplated by using the following technologies and techniques:

- Widespread use of ISO CMOS technology, presently with 5 µm and 3 µm features sizes; 1 µm feature sizes will be achieved by the end of the 1980s with low power consumption and medium speed (up to 25 MHz).
- Use of gallium arsenide technology for optical fiber applications, voice processing, and very high speed circuits.
- Use of bipolar technology, including high voltage applications.
- Widespread use of custom design circuits based on the use of a standard "cell" library.
- Increasing use of arrays.
- Restricted use of full custom design of LSI circuits.

Since 1980, when the first integrated circuit to be produced in Spain was designed at SESA RC with 3000 transistors, work has continued to progress, and will continue in order to achieve state-of-the-art integration levels.

Information Systems

The main activity in this area is oriented towards implementation of the ISDN concept in national networks, particularly in Spain, taking into account all the implications in the long distance network and subscriber (end user) network. An ISDN field trial based on the ITT 1240 Digital Exchange will be carried out in collaboration with CTNE, the Spanish telephone Administration. The research center, a pioneer in the study of digital and integrated services networks, is undertaking advanced investigations and development of high level protocols for implementing user network services, and formal (mathematically-based) definition methods to relate user specification and advanced terminal systems.

Many existing telephone subsets will be replaced by more sophisticated equipment in which ergonomic design and voice controlled operation will give the user the friendly system he desires. In particular, SESA RC will develop a digital key system and a voice/data digital telephone.

Teletex and facsimile applications are already under development at SESA RC.

SESA RC undertakes applied research for electric power companies. The Tracof fiber optic communication and control system was designed for use in power distribution areas where conventional systems would be subject to considerable interference.

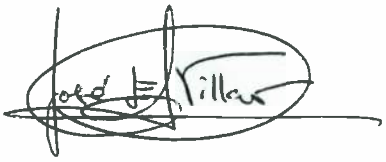
Optical Communication
The extremely wide bandwidth of transmission on optical fiber combined with microelectronics technology will, by 1990, make it economically feasible to incorporate new broadband services (video, audio, etc) into the telecommunication network. Applications for optical fibers range from subscriber loops to high capacity links. Their use in submarine cables has a great future as a result of the large repeater spacings that will be possible.

Other applications are also important, but in some cases require special development. Examples are power cables with an optical fiber core for communication, special fibers for military applications, and control systems with optical sensors (e.g. telemeasurement systems).

SESA RC activities will be mainly oriented towards the systems area, and the transfer and adaptation of technology. Programmes in collaboration with CTNE will be established (e.g. a wired city project), while in the nontelephony area, applied research for electric power companies will be of importance.

Conclusions

The Standard Eléctrica Research Center is the leading telecommunication and electronics laboratory in Spain. It provides an entry door for advanced technology into the Spanish telecommunication and related industries by virtue of its association with ITT laboratories in Europe and the United States; many technological breakthroughs in the areas of telecommunication systems, programming, microelectronics, optical communication, and so on, will use this route into Spain. At the same time other ITT units will benefit from the center's expertise in teletraffic and network planning.



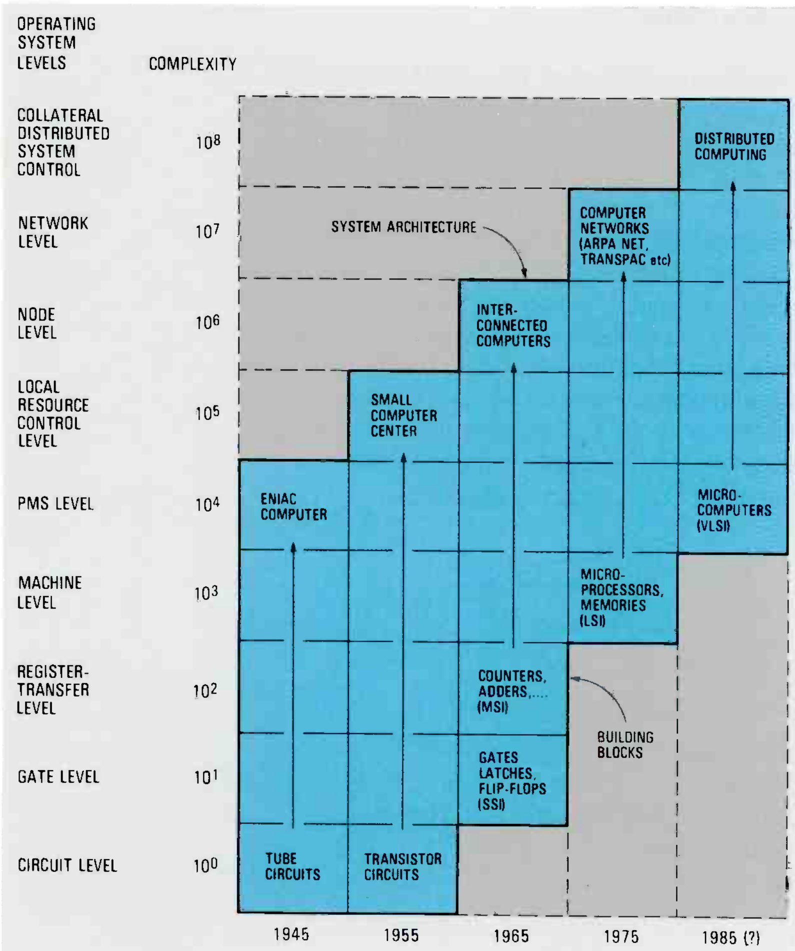
J. E. Villar
Director
Standard Eléctrica Research Center,
Madrid, Spain

High Technology: the Key to Growth

The technologies that are important to the future of the telecommunication industry are becoming more diverse and less well defined. Microelectronics is at the forefront of the revolution, but as the limits of integration are approached, systems design, programming, and artificial intelligence will play more important parts.

Introduction

Worldwide there is almost a flood of articles, television programmes, and conferences aimed at convincing both specialists and the public that technology is the key to a new economic upswing. Bell Telephone Manufacturing Company has been convinced of this for many years, and has based its future strategy and product developments on this premise. Ten years ago BTM put this belief into practice by creating an advanced research center to prepare the company for the next generation of telecommunication systems.



Evolution of system architecture and basic building blocks.
PMS - processor memory switch.

The center collaborated as part of a multinational team in the development of the ITT 1240 Digital Exchange, which is now a working product with exchanges in several countries. However, the research center's objectives remain the same: to prepare the company for the next generation systems, but with a slight twist.

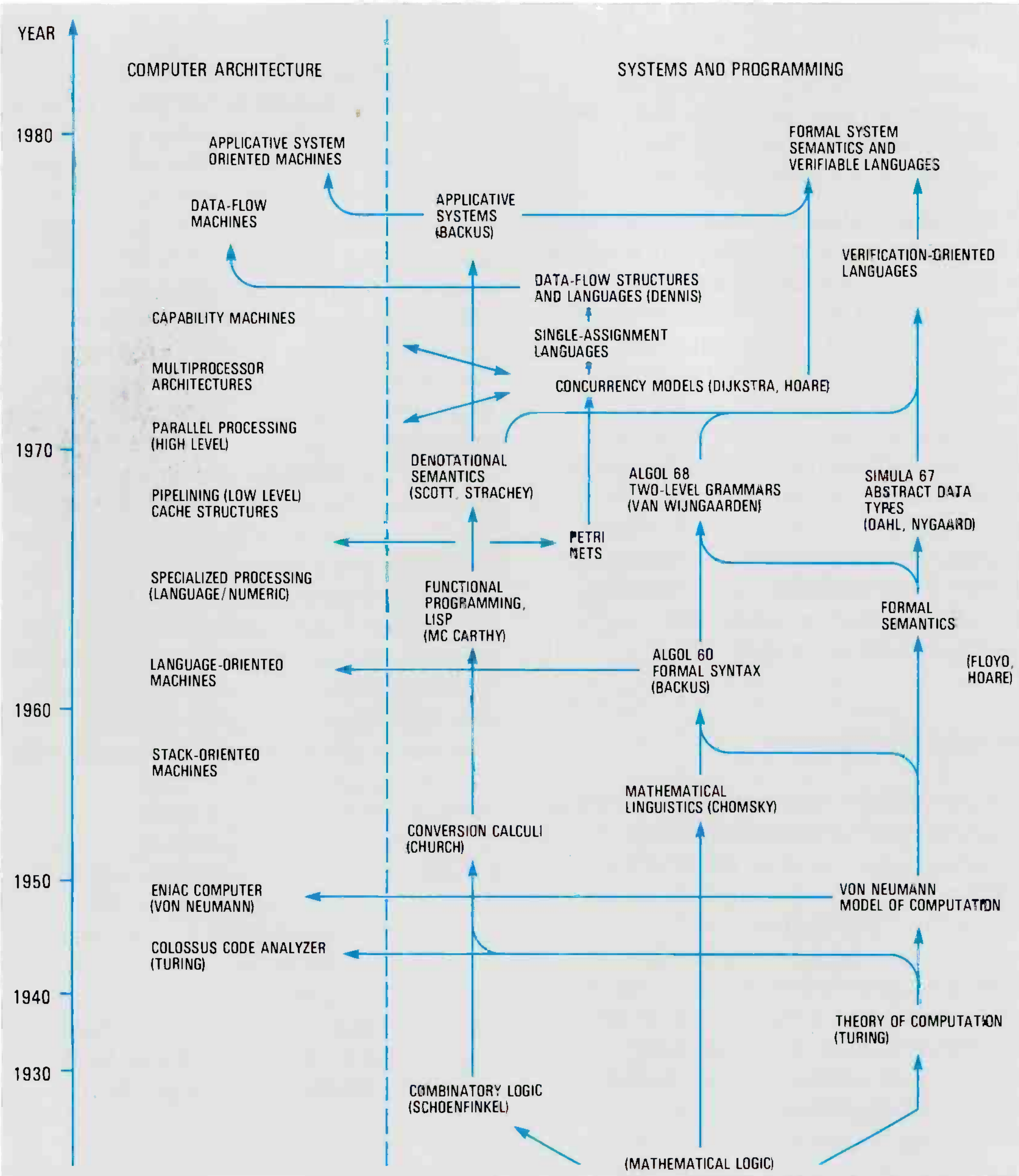
R&D costs have been soaring, specifically as a result of staff increases for advanced research, which are predicted to grow over the next five years by more than 20% per annum. Thus it is essential to maximize efficiency and planned interactions with other ITT research centers. Even contacts with non-ITT laboratories are mandatory if BTM is to possess expertise in every aspect of telecommunication technology.

Prime candidates for long-term research collaboration are university laboratories. In Belgium, the government strongly supports the move towards rationalization in research, coupled with greater involvement in telecommunication technologies. One particularly good example is Superlab with its 250 specialists in VLSI, where the VLSI activities of three universities will be concentrated. Similar initiatives will follow, and in each case the BTM Advanced Research Center will aim for close collaboration.

Nevertheless, as in every country, the main challenge in Belgium over the next five years will be the training of a new breed of technical experts.

Telecommunication Technologies

Some five years ago it was easy to list all the telecommunication technologies. The list now is broader and less well defined. Some products, such as local area networks, should at this moment be catalogued as a technology, Webster's dictionary defining technology as "the science of the industrial arts". In this contribution only a few



Evolution of computer architectures.

technological trends are discussed, primarily relating to work at the BTM Advanced Research Center.

Systems and Software Research

More complex and reliable systems than those of today, together with the scarcity of R&D resources, create a need for a more formal design methodology. Ideally, marketing inputs should be translated automatically into formal specifications which can be compiled into hardware circuits and software. For the foreseeable future, such an approach appears unrealistic, but rapid advances are being made and formal system design can benefit from concepts in the following areas:

- Formal language theory deals with the syntactic aspects of formal languages, that is, the characteristics of strings, or sequences of symbols, solely on the basis of their form and irrespective of any intended meaning.
- Automata theory handles the structure of abstract machines that accept input strings and produce output strings according to certain rules.
- Dynamic logic is used both to express the meaning of language constructs and to prove the correctness of programs by considering pre- and postconditions which are satisfied by the program state.
- Denotional semantics assigns meaning to programs and language constructs by defining a mathematical function (the

meaning function) describing state transformations.

– Axiomatic definition of abstract data types which describe, by means of a set of axioms, the properties of the operations of a system module.

This nonexhaustive overview illustrates that there are several approaches with different emphases and degrees of abstraction to cover the same area: systems, programs, and their meaning. On the other hand, implementation requires that ultimately the design be represented in a single, implementable form, even if different formulations have been used at the abstract level. Thus the designer must be able to switch smoothly from one formulation to another, while preserving the integrity of the design. A mathematical background will, more than in the past, become a prerequisite for designers.

Artificial Intelligence

Artificial intelligence is gradually becoming a standard and accepted technology in universities and industrial laboratories. Efficient and productive applications are waiting around the corner.

An artificial intelligence approach considers the artifact under study, say a software package, a VLSI circuit, an office automation system, and a computer integrated manufacturing system, as a collection of objects with mutual interactions. To realize such an artifact, a number of tools (which are now under development) are required:

– Descriptive languages capable of describing the generalities and particularities of the object and the artifact.

– Techniques for capturing knowledge about the artifact into a computer database, or knowledge base. This requires the availability of knowledge description languages.

– Expert systems, which can use the knowledge base to help designers in their development work.

Most present research work indicates that applicative programming languages and specialized computer systems will be needed. LISP (list processor) machines are currently important contenders.

A major application for artificial intelligence systems will be in VLSI computer-aided design systems.

Microelectronics

The BTM Research Center has two departments devoted to microelectronics: a VLSI design center in Antwerp and a processing laboratory in Ghent. In the past, the latter has developed *n*MOS, CMOS, combined MOS-bipolar, and high voltage technologies. This resulted in 1982 in the decision to establish a wafer fabrication plant in Oudenaarde to process custom LSIs developed by BTM or by outside design centers. During the startup phase, most wafer production will be oriented towards the LSIs used in the line circuit of the ITT 1240 Digital Exchange. High voltage technology, the development of which was started in 1978, allows high voltage devices (up to 400 V) and low voltage logic to be combined on one chip.

The VLSI Design Center in Antwerp has interactive design systems, minicomputers, and test facilities interconnected by a local area network with access to the three mainframe computers in BTM. In addition to VLSI design, this center actively investigates future design techniques in collaboration with universities and other industries. There is a strong link with the systems and software department in the Advanced Research Center. Other activities are centered around advanced design concepts using gallium arsenide, not only for high frequency applications in mobile communication systems, but also for next generation electro-optical applications.

Conclusions

Despite its relatively short existence, the BTM Advanced Research Center has already made major contributions in telecommunication technology, systems and software research, artificial intelligence, and microelectronics. The strong foundations built in these areas will be the basis for further advances, keeping BTM in the forefront of advanced technology.

W. De Kinder
Managing Director
Bell Telephone Manufacturing Company
Research Center, Antwerp, Belgium

From Voice to Video Communication

New technologies are revitalizing and expanding services in the telecommunication industry. A wide range of new voice and non-voice services will shortly be introduced, initially based on an ISDN; subsequently they may be linked with an integrated broadband network.

Introduction

The world is already entering a new telecommunication era based initially on the integrated services digital network and subsequently on integrated broadband networks which will offer a diverse range of new services. The expected saturation of the existing telephone service in many countries, and the increase in new narrow band services in Germany are illustrated in Figures 1 and 2. The evolution from data and voice communication to text, graphic, and video communication (Figure 3) will be led by progress in the key technologies of microelectronics, fiber optics, and digital transmission and switching.

The cost of transmission capacity will be so dramatically reduced by these technologies over the next ten years, that videophone may replace the telephone in the 1990s, so that telecommunication achieves a status that can be compared to "natural communication".

If videophone can be realized cost-effectively using fiber optic transmission, it will be possible to integrate all other telecommunication services (e.g. services offered by integrated services digital networks and interactive cable television) with the broadband network at an economic cost. The conditions necessary for the economic introduction of an integrated broadband fiber optic network are:

- services offered initially via an ISDN would have to be offered at essentially the same price as ISDN services using traditional twisted copper wire pairs
- television via a broadband network should cost about the same as coaxial cable television systems with comparable features
- videophone services would have to cost less than twice the existing voice telephone service.

Meeting these requirements is a challenge for research and development and a major opportunity for the telecommunication industry.

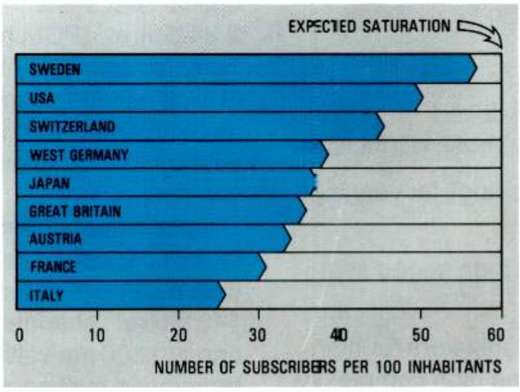


Figure 1
Expected saturation of the telephone service in nine countries.

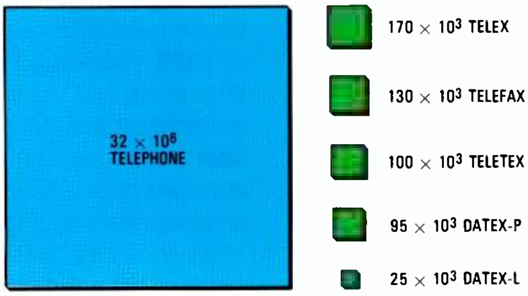


Figure 2
Number of subscribers expected to use the main narrowband services in the Federal Republic of Germany in 1990.

Technology and System Aspects

In order to realize an integrated broadband network, a number of technologies must be developed further.

VLSI

The state of the art in VLSI microelectronics is characterized by 3 to 1.5 μm feature sizes with between 100000 and 500000 transistor functions per chip in *n*MOS and CMOS technology. In bipolar technology the current status is 0.4 ns gate delay with up to 10000 transistor functions per chip. The exact values in each case depend on the semiconductor manufacturer.

This status allows the monolithic integration of electronics for a broadband transmission and switching network, but not with the minimum number of different chips as determined by optimum partioning of the system to provide the required modularity, so that services can be added as they are demanded by subscribers with a minimum of investment.

By 1985/86 it is predicted that feature sizes of less than 1 μm will be possible with one million transistor functions per chip in *n*MOS and CMOS technologies available for production. This will make it possible to develop broadband network electronics in which the VLSI chips will correspond to system partitioning. Parallel to the extensive use of MOS technology, a number of other technologies will be important in specific building blocks for a broadband communication network. These will include:

- gallium arsenide technology for very high speed circuits
- bipolar technology for high speed and power
- amorphous thin film transistors for high voltages at low cost and high complexity.

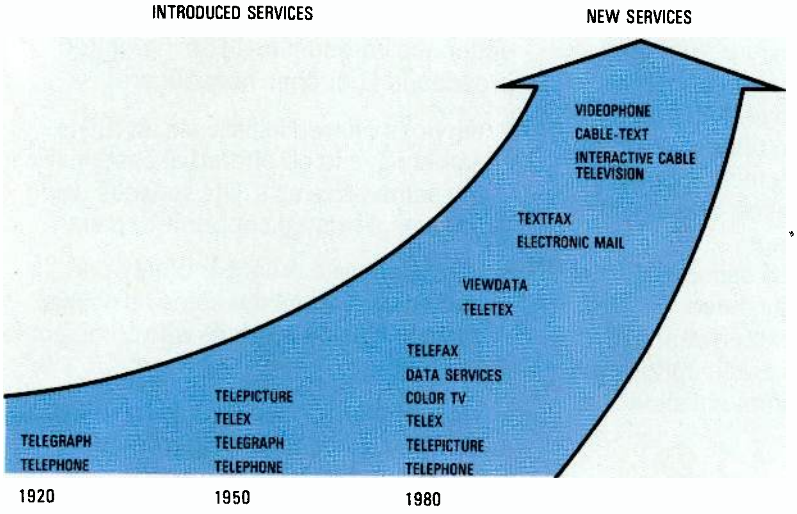


Figure 3
Evolution of telecommunication services showing how the traditional services will be supplanted by new services towards the end of the 1980s and beyond.

Systems and Terminals

The next five to eight years will be needed to develop stage-by-stage the first economic version of an integrated broadband network that may include ISDN, cable television, and videophone services. In addition to the above advances in VLSI, this will require advanced development of optical fiber and programming technologies, and improved system architectures.

Technologies for the second generation integrated broadband network are under consideration, and in the early stage of basic research. Some of these technologies will not be included in actual products before the end of the century.

Another important problem for the introduction of new services is the development of low cost terminals of a high technical quality that are easy to use and provide functions demanded by the user. Research is needed into the following areas:

- flat screen displays for television and data, and suitable control circuits
- scanners, printers, and mass storage for textfax
- user guidance in home and office communication systems or workstations.

Further research is aimed at realizing a nearly paperfree office in the 1990s.

High definition television which is. flickerfree and provides extremely high resolution will be the next stage in television and videoconferencing, but worldwide introduction cannot be expected much before the year 2000. The necessary transmission bandwidth will be provided by filter optic technology.

Fiber Optics

The best result to date in optical fiber long-haul transmission is a laboratory model which transmits a 2 Gbit s^{-1} signal over a distance of 51.5 km without repeaters using monomode fiber. It is likely that commercial optical fiber systems operating at 2.24 Gbit s^{-1} (PCM hierarchy step) with repeater spacings of up to 20 km can be available in the second half of the present decade. Thus, such systems can be used in economic evaluations of broadband services.

Optical subscriber lines using graded-index fiber can be used without repeaters over distances of more than 5 km; two 140 Mbit s^{-1} channels (one at 850 nm and one at 1300 nm wavelength) from the broadband exchange to the subscriber and one in the opposite direction, will be installed in the BIGFON field trial system of the Deutsche Bundespost towards the end of 1983, providing ISDN, interactive cable television, and videophone services based on bidirectional transmission over a single fiber per subscriber. Economic production versions of this subscriber loop and broadband switching are expected between 1987 and 1989 for independent introduction of the mentioned services (i. e. ISDN,

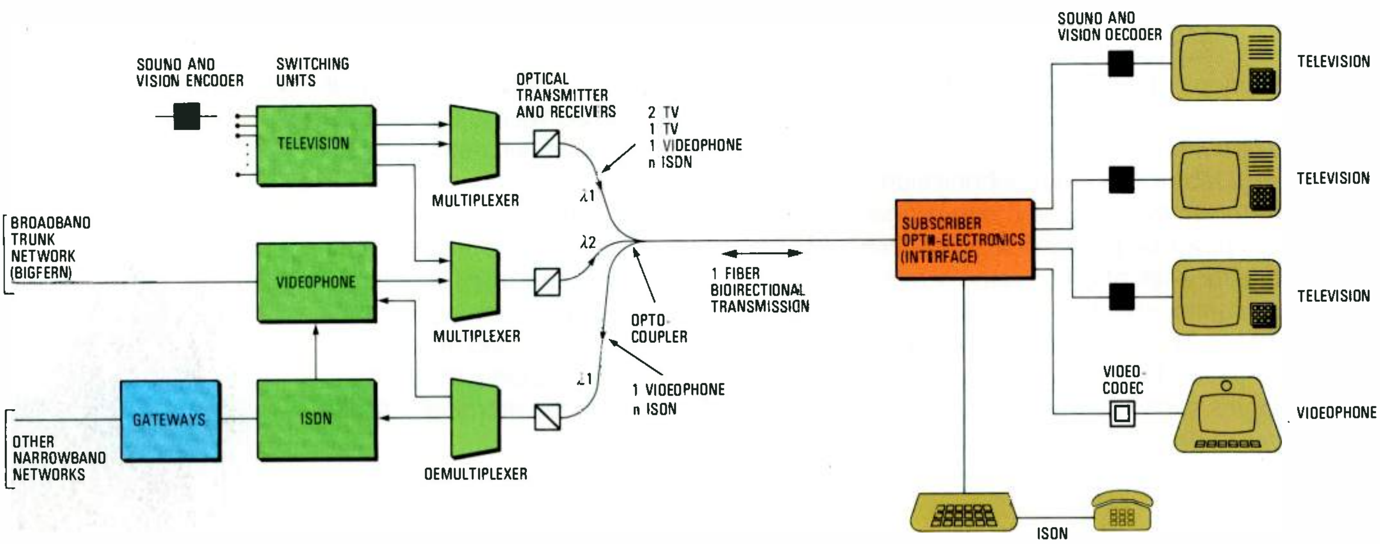


Figure 4
Block schematic of the broadband integrated glass fiber optic network developed by the SEL Research Center.

interactive cable television, videophone).

Optical television distribution systems as a preliminary step towards broadband communication systems are under discussion in several countries, and in the introduction phase in France.

Optical components for the systems mentioned above are being developed in the laboratories and some are already available. However, prices will have to decrease considerably for the introduction of broadband communication systems, but this is a mass-production and not a technical problem. Current forecasts anticipate that it will be solved using existing technologies.

Today optical fiber technology is still far from a mature technology: further improvements and lower costs are expected as a result of:

- increasing the transmission speed to 10 Gbit s^{-1}
- using wavelength multiplexing and coherent detection (gain of more than 10 dB in signal-to-noise ratio)
- development of monolithic integrated components of optical transducers (lasers, photodiodes) with electronic circuits (driver, amplifier, etc)
- development of integrated optics with direct light amplification
- introduction of new optical fibers operating at long wavelength (around 5 μm) with very low attenuations (less than 10^{-3} dB km^{-1}).

Broadband Integrated Glass Fiber Optic Network: BIGFON

The SEL version of the BIGFON field trial system is shown in Figure 4 with its main building blocks:

- tone and video codecs (coders/decoders)
- broadband switching modules (less than one chip per subscriber)
- multiplexers, gateways, interfaces, and control units
- optical transmitters and receivers
- optocouplers.

The final stage of the electronics could be a single-chip version of each of these main building blocks. In the above context, economic means that videophone switching and transmission in the subscriber area can be provided at a cost that is less than twice that of the telephone service. Cost studies have shown that this could be achieved for 140 and 70 Mbit s^{-1} per video channel in the second half of this decade, if demand is sufficient for mass production of equipment to be achieved.

For long-haul transmission it is intended

Home station for the BIGFON system.

to reduce the bit rate for videophone to the 2 Mbit s^{-1} COST (cooperation in science and technology of the EEC) standard or 8 Mbit s^{-1}. Using the 2.24 Gbit s^{-1} optical fiber system mentioned earlier and assuming 2 Mbit s^{-1} for a videophone signal, it can be shown that long-haul videosignal transmission will be possible at prices less than those for a telephone channel which is using conventional analog transmission on coaxial cable. This shows that in addition to VLSI and optical fiber systems, technologies such as videosignal encoding and data compression are of significant importance.

Conclusions

Over the past decade there has been enormous progress in the key technologies used in telecommunication systems. However, evolution is continuing at an increasingly rapid pace, leading the way to a new era of telecommunication. The Standard Elektrik Lorenz Research Center is closely involved in many of these key technologies, and in particular those that relate to the realization of a future broadband integrated communication network and advanced terminals.

Research into materials, components, programming, system architectures, and human factors engineering will continue to increase throughout the present century. The information society, and the telecommunication systems that will support it, is only in the morning of its life.

H. Ohnsorge
Director
Standard Elektrik Lorenz Research Center,
Stuttgart, Federal Republic of Germany

ITT Papers Presented at Telecom 83

Introduction

Representatives of seven ITT companies are presenting papers at Telecom 83. These cover a variety of topics ranging from signaling protocols, through office communication systems, to integrated services in a future ISDN. These papers are being presented at the following sessions in the technical symposium:

Specialized Networks (Session 2)
A Distributed Operating System Based on UNIX and Local Networking,
A. J. M. Wambecq

Switching and Signaling (Session 3)
A Signaling Protocol for Multiservice ISDN Access Suitable for Circuit and Packet Switching,
S. R. Treves

Telecommunication Services (Session 6)
System Modularity, Equipment Distribution, and Service Integration in Business Communication Systems,
E. Sletten and *B. E. Jensen*

Advanced Text Communication – New Features and Devices for the Telex and Teletex Services,
D. Unger

Integrated Services Digital Networks (Session 8)
User Requirements for Telecommunication Integrated Services,
R. Smith and *R. K. Heldman*

Terminals (Session 9)
Inexpensive Digital Encryption Systems for Cordless Telephone Secrecy,
V. Baroncini, O. Brugia, G. Campanini, and *W. Wolfowicz*

Networks (Session 11)
Pragmatic Planning for the Introduction of Non-Voice Services in Existing Ana
Networks,
F. Casali and *E. Lera*

Summaries of the main points in each of these papers are given on the f

A Distributed Operating System Based on UNIX and Local Networking

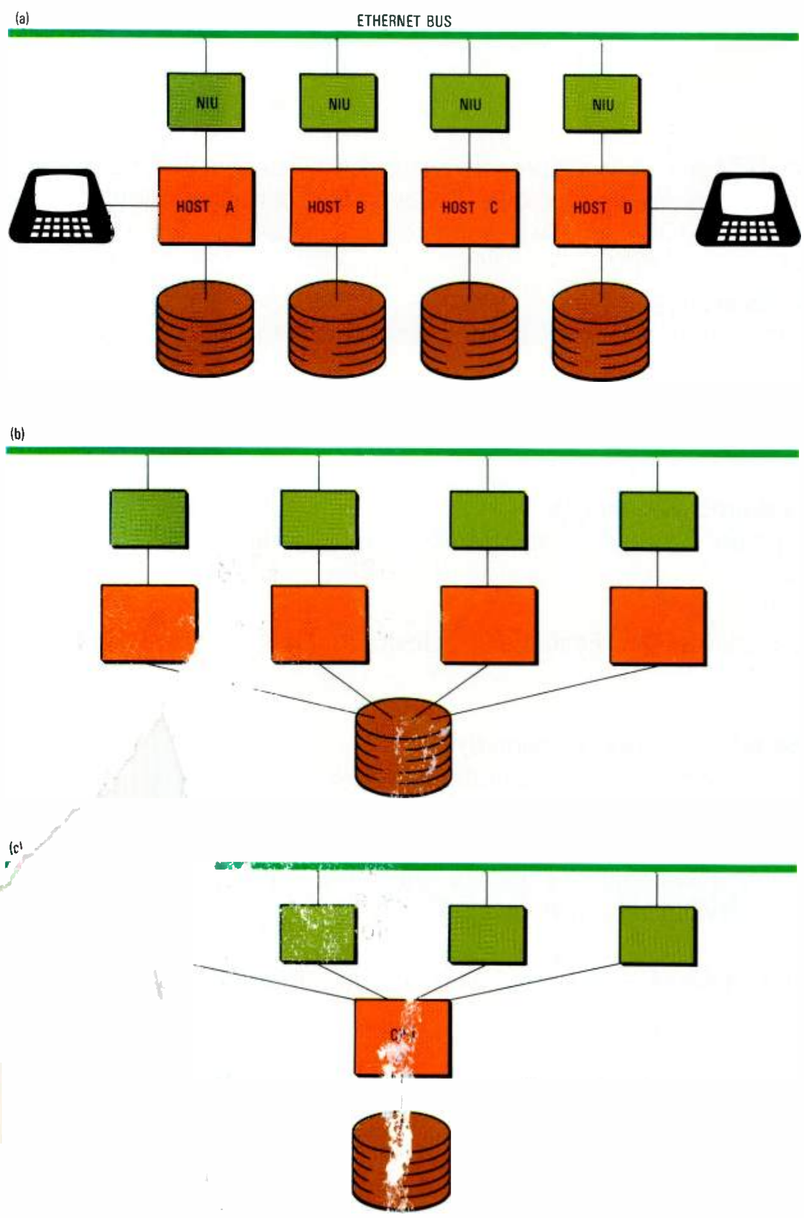
A. J. M. Wambecq
Bell Telephone Manufacturing Company,
Antwerp, Belgium

The NETIX* distributed operating system provides the user with access to the combined resources of all the computers associated with a LAN (local area network) as though these resources resided in a single large computer. The development is based on the distribution of intelligenc between hosts and network.

NETIX is based on three building bloc

- UNIX software, an operating system originally designed for the PDP family of hardware, and now becoming a *de facto* operating system standard for 16- and 32-bit computer hardware.

* A trademark of ITT System



– NIUs (network interface units), which free the processors from the time-consuming communication tasks involved in distributed processing.

– Local area network (LAN), including the intelligence that resides in its NIUs.

NETIX is designed to make the processors, the NIUs, and the LAN work together so that system users are aware only of a single, networked machine that unifies the files of all the processors, and runs processes on whatever hardware is most appropriate. This activity is transparent both to users and to user programs. The result is uniform access to all resources (e.g. processing power, disk storage) by devices located throughout the network. Each processor can work independently of the others, and each host processor can grant other machines access to specific local resources. These capabilities are based on three important design features:

– completely distributed machine name database, giving every processor the means to access every other processor, without the need for a central name server

– naming and addressing convention that extends the standard UNIX file system so that logical names of machines are accessible to other machines throughout the LAN

– enhancement of the UNIX protection mechanism that makes it possible to verify the right of access of users located throughout the LAN.

The only visible extension to the UNIX software is a network directory, distributed over all machines with access rights to the network. It contains the logical names of network resources accessible from a particular host. The kernel of the NETIX operating system recognizes the names of remote resources during the interpretation of logical names, then sends messages to the destination processor via an IKC (interkernel communication) mechanism. The receiving part of the IKC creates a server process which handles the remote request locally, then returns the result via the IKC to the originator of the request. Interkernel communication is based on the exchange of messages that contain address information in a machine-independent (logical) form. IKC messages are directed to the LAN via high speed links from a host processor to a network interface unit. The network recognizes the logical addressing information, and performs such network-specific functions as error recovery, logical-to-physical-address translation, routing, and broadcasting. Interprocess communication for server processes is built on top of the IKC mechanism. It is established by adding the necessary synchronization between the processes, and imposing a structure on the contents of the nonaddress part of the IKC messages.

The NETIX concept also includes the following features:

– Error recovery and graceful degradation. Failure of one host only affects access to that host's local resources. Other network components are not disturbed by the failure of one (or more) host(s).

– Enhancement of network functions (e.g. network services such as printer queuers, or access to other networks via gateways).

- Access to NETIX-like machines. The structure of the IKC and interprocess communication messages is well defined. Systems emulating the effects of these messages can be an integral part of the network.
- Access to NETIX machines without local storage (e.g. workstations).

The NETIX network operating system can be used as a building block. It is a universal distributed system with applications in the office world, plant control, program development, and many other areas. NETIX itself is the first major application built on the local area network, and a proof of the feasibility of a distributed approach.

Signaling Protocol for Multiservice ISDN Access Suitable for Circuit and Packet Switching

S. R. Treves
FACE Finanziaria, Milan, Italy

The subscriber terminals to be connected to an ISDN will include analog voice telephone subsets; data terminals operating at different user rates and in start-stop, synchronous, and packet modes; and digital multiservice terminals and PABXs. Protocols are needed to enable these different terminals to access the public telephone network; at the same time, access to dedicated circuit- and packet-switched data networks must also be envisaged. Based on an analysis of the requirements of a digital loop signaling protocol, field trials of such a protocol will be conducted at Bologna, Italy, early in 1984.

Field Trial Configuration

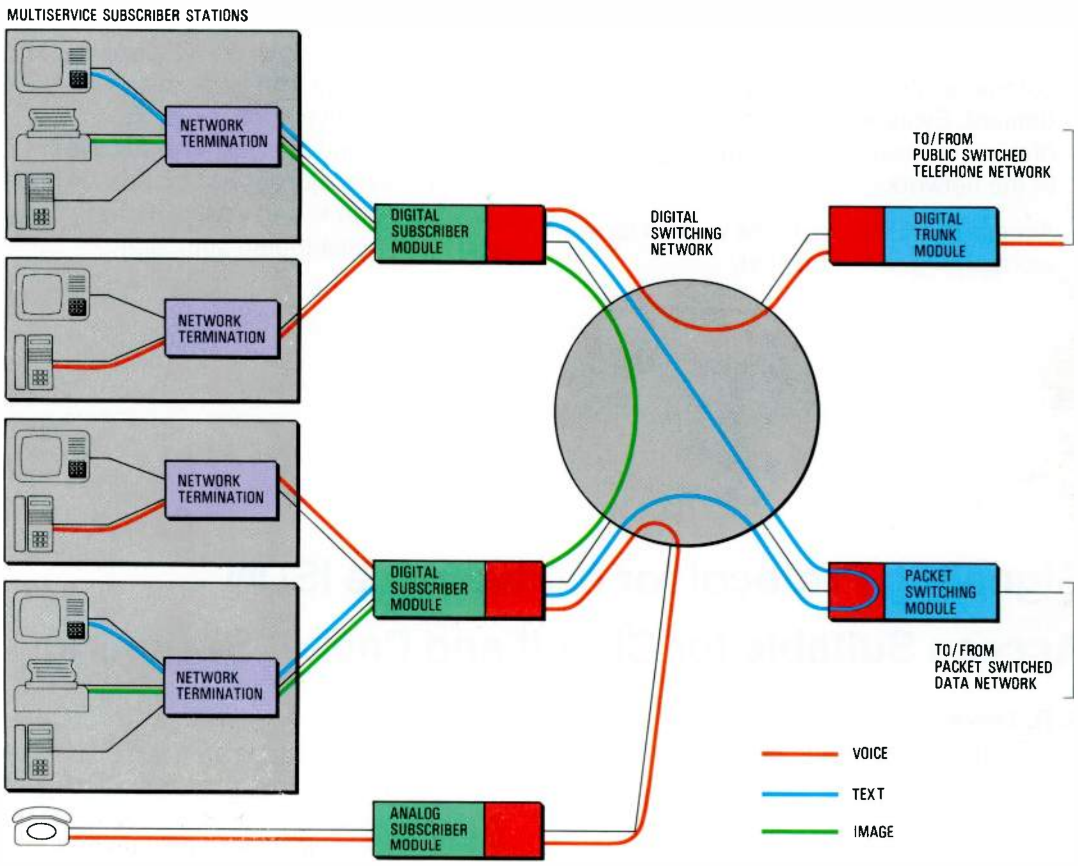
In the field trial, an ITT 1240 terminal exchange, initially equipped for telephone subscribers with analog subsets, will be enhanced by the inclusion of subscribers operating digital multiservice equipment. The objective is to demonstrate the full capability of the ITT 1240 Digital Exchange to integrate voice and non-voice services, including the integration of circuit- and packet-switched data services in an existing ITT 1240. It will also show the feasibility of accessing a dedicated packet-switched network through an ITT 1240 terminal exchange, and of operating a full duplex digital subscriber loop at the 144 kbit s^{-1} user rate.

B + B + D channel access will be used, with circuit-switched information carried by B-channels, and signalling and packet-switched information by the D-channel. A B-channel will also be used to convey packet calls towards the common CCITT X.25 resources; in this case [illegible] procedure will be used to set [illegible] 64 kbit s[illegible] connection th[illegible] 1240 digital switching netwo[illegible]

Initally, the follow[illegible] be demonstrated:

- circuit-switched telephone calls between digital and/or analog subscribers for local, incoming, and outgoing traffic
- circuit-switched facsimile calls on either of the two B-channels
- packet-switched teletex calls between X.25 terminals on the D-channel and on a B-channel; cross-connections, B-channel to D-channel, or *vice versa*, are also possible
- voice or, alternatively, facsimile call on one B-channel for circuit-switched service and simultaneous teletex calls on the D-channel (for packet-switched service) or on the other B-channel
- simultaneous voice and facsimile calls on different B-channels and teletex calls on the D-channel.

In a second phase of the field trial, packet-switched connections with dedicated packet



Telematic field trial in an ITT 1240 ISDN terminal exchange.

switching nodes related to both B- and D-channels will be demonstrated.

Multiservice Subscriber Stations

A variety of terminal equipment will be provided for multiservice digital subscribers, including the DT80 digital telephone, which is characterized by 4-wire, full duplex transmission [illegible] kbit s^{-1}; ITT 3150 teletex terminals operating at 2400 bit s^{-1} in the packet-switched mode; and ITT 3535 facsimile Group 3 enhanced terminals operating in the telephone mode at 9600 bit s^{-1}. Finally a line terminal will be equipped on a subscriber's premises, supporting a full duplex B + B + D channel at a user rate of 144 kbit s^{-1}, or a B + D channel at a user rate of 80 kbit s^{-1}, using a hybrid echo canceling technique. A 3B-2T line code will be used; the line terminal will include a special filter to prevent crosstalk on audio broadcasts distributed over telephone subscriber lines.

The main advantages of the proposed protocol are:

- No modification is necessary in the packet field format (as defined in CCITT Recommendation X.25).
- Only one module need be provided in the ISDN terminal exchange for interfacing with the various user terminals, because in all cases the same frame-mode protocol is used in the digital subscriber loops.
- The complexity of protocol translation required to access circuit- and packet-switched dedicated networks is reduced.

Finally, the adoption of a common transport vehicle for the signaling of all services leads to substantial commonality between the various versions of the call control software in the terminal exchanges. This provides an appropriate basis for defining a single call control software package common to all services, which will ultimately be necessary if services are truly to be integrated.

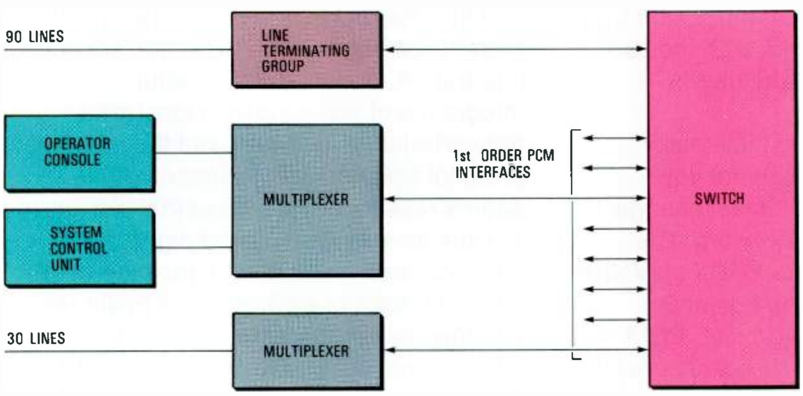
System Modularity, Equipment Distribution, and Service Integration in Business Communication Systems

E. Sletten
B. E. Jensen
Standard Telefon og Kabelfabrik, Oslo, Norway

The rapid growth of data processing, particularly distributed data processing, has given rise to an equally rapid growth in the volume of non-voice traffic carried on telecommunication networks. The industry is being called upon to provide easier access to information services and easier movement of large volumes of data, resulting in a requirement for service-integrated telecommunication systems.

Cost-effective semiconductor components for converting voice traffic to digital form and back to analog form have resulted in new solutions for digital transmission and switching. With both voice and non-voice traffic in digital form, a single common digital business communication system suggests itself as a solution with considerable potential for improved efficiency, greater flexibility, and cost effectiveness.

ITT 5500 business communication system block diagram.



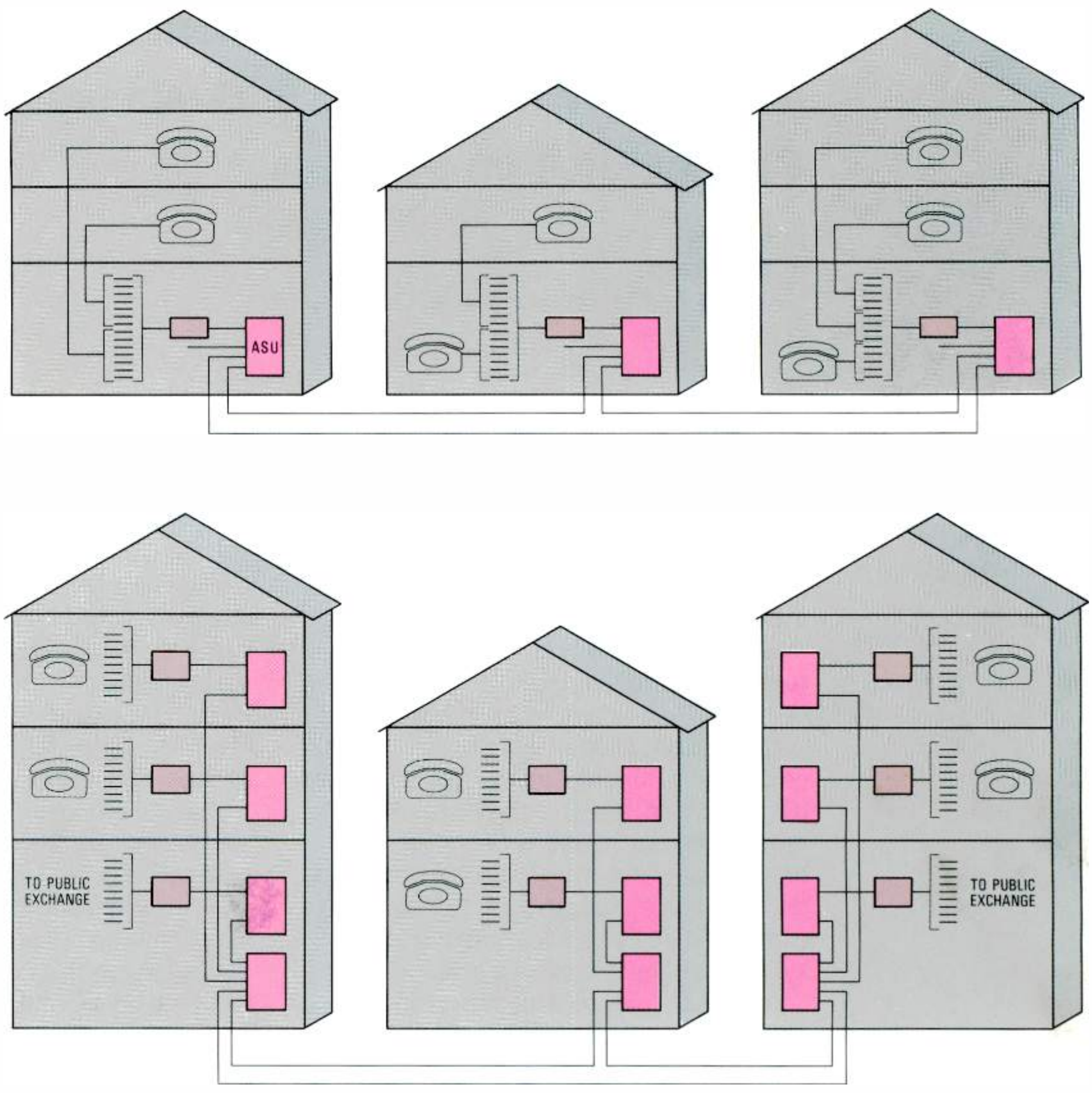
ITT 5500 Business Communication System

Following an extensive research and development programme on system design, digital switches, multiplexers, and network control units, STK (Standard Telefon og Kabelfabrik) developed a small general purpose digital switch that is the core of the ITT 5500 business communication system. The microprocessor-controlled digital switch has eight standard first-order PCM (pulse code modulation) ports that can be switched through without internal blocking. It also has a first-order PCM subscriber multiplexer system for 30 user channels, in which the required line interfaces can be equipped on a per-channel basis, as well as a line terminating group for 90 user channels. Other features are an operator console and a system control unit.

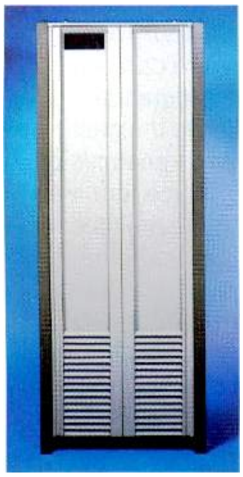
Using these components, a digital PABX or business communication system for any application in the range from one hundred lines up to several thousand can be built simply by combining the required number of system modules. The standard PCM interface between digital switch and multiplexer system facilitates geographical separation of these modules. In principle there is no limitation on distance so long as appropriate transmission facilities are provided. A sophisticated common channel signaling system implemented between digital switches ensures that the system appears to users centralized, whether or not the equipment is distributed. The equipment distribution feature can be exploited to solve service integration problems. Problems relating to the multiwire nature, interface variety, and transmission distance limitations of non-voice terminals can be overcome by using the multiplexer system as a remote unit located in the immediate vicinity of the user terminals, whether they be telephones, non-voice terminals, or data processing host interfaces. Multiwire connections can thereby be limited to the short distance between terminal and multiplexer, and there is a real potential for saving on house wiring since only 4 (or 8) wires are needed to connect the multiplexer (with as many as 30 users) to the digital switch.

The most attractive feature of the modular system approach used in the ITT 5500 is its flexibility. Equipment may be located

The flexible of the ITT 5500 concept allows both centralized (above) and distributed (below) equipment configurations.
ASU - digital switch (autonomous switch unit).



ITT 5500 business communication system.



centrally in the traditional manner, or it may be distributed as described, with module configurations tailored to the user's requirements.

Truly service-integrated business communication systems are not yet common, but this situation must change dramatically in the next few years. The ITT 5500 system is a digital PABX approach to service integration in the business environment, based on 64 kbit s^{-1} PCM digital transmission for the user channels. It is argued by some that 64 kbit s^{-1} is too limited for many non-voice applications, and that therefore local area networks are a better basis from which to pursue service integration. However, successful integration of voice traffic in local area networks is not available, and the interface/protocol situation is still unresolved. It seems reasonable to expect that the future will see an amalgamation of digital PABX and local area network to exploit the best characteristics of each in future business communication systems. However, international standards need to be clarified, and actual user requirements need further investigation.

Advanced Text Communication – New Features and Devices for the Telex and Teletex Services

D. Unger
Standard Elektrik Lorenz AG, Pforzheim,
Federal Republic of Germany

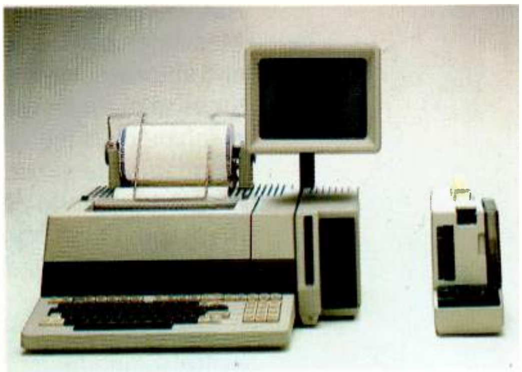
Since the mid-1970s, the availability of high performance microprocessors and stored program control has brought about a revolution in text communication. The ITT 3000 teleprinter and the ITT 3150 teletex terminal are representative of the new generation of equipment, offering improved efficiency and new text communication features.

ITT 3000 Teleprinter

Modular design facilitates the configuration of equipment to meet customer requirements. The basic model ITT 3000 teleprinter, for example, has a battery-powered semiconductor message store; it can be enhanced by adding a paper tape attachment or floppy disk storage and a video monitor. The random access memory is extendable from 8 to 48 kbytes; the floppy disk provides 72 kbytes of memory. New features include:

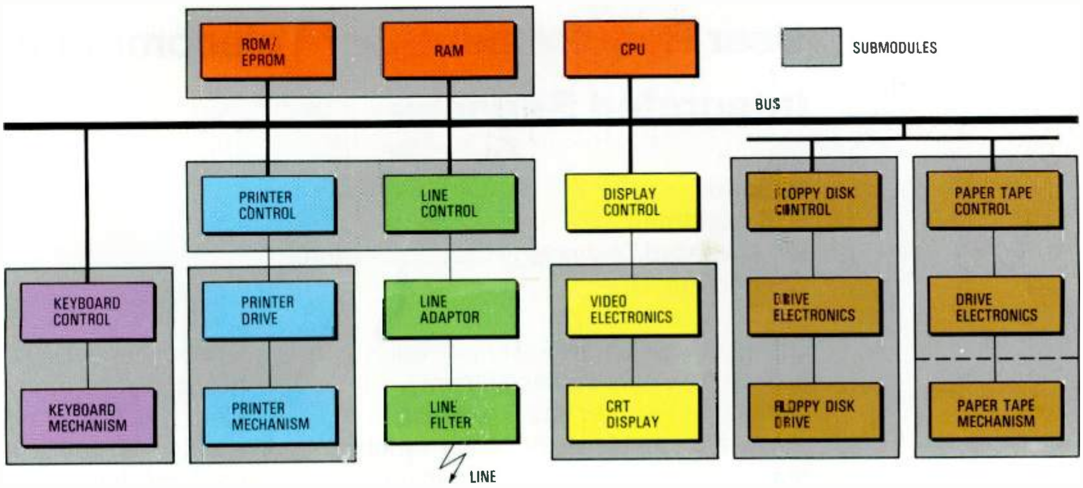
Improved message preparation and editing. Advanced text editing facilities are provided, including functional keys (e.g. search; insert or delete character, word, or line). Automatic wordwrap in both directions enables the operator to type the message continously into the message store.

Formatting, tabulation, and the use of standard character strings are also available. Messages are automatically numbered, and a message list is generated by the system. Before transmission, changes can be made by recalling the message from memory, using either the message number or a message name assigned by the operator.

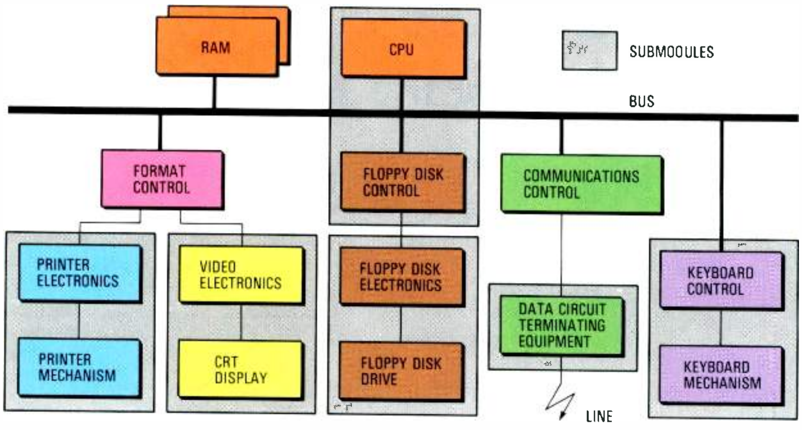


ITT 3000 modular teleprinter.

Improved operator efficiency. While keying in text, the operator need not be interrupted by incoming messages. These are automatically transferred into the message store in background mode, and displayed or



Block schematic of the ITT 3000 teleprinter.



Block schematic of the ITT 3150 teletex terminal.

printed out only after completion of the outgoing transmission. The chances of a lost message are minimal: the storage device is battery-buffered, and a printout is forced if the store is full.

Automatic message transmission. Messages can be entered into a send list and automatically transmitted at preselected times to preselected destinations. The machine dials the required connection and compares the subscriber number and answerback code before sending the message. Other transmission capabilities include short code dialing and repetitive dialing.

Maintenance costs have been minimized by designing for high reliability and ease of servicing.

Measures to reduce service costs include the use of aids for assembly/disassembly, and the replacement of screw joints by snap-in fittings. A faulty submodule can be replaced without disassembly of other exchangeable submodules.

ITT 3150 Teletex Terminal

The teletex service will become an increasingly important text communication medium. If standardization is limited to communication-related features, local features can be designed to offer a wide variety of device types, ranging from storage typewriters to text stations and wordprocessors. Since the secretarial workstation will be one of the main user types, the combination of typical typewriter functions, text processing, and message transmission can offer a substantial improvement in efficiency.

An example of a secretarial workstation is the ITT 3150 teletex terminal. A CRT display (24 lines of 96 characters) facilitates text entry and editing. The 305 mm (12 inch), high-resolution screen displays characters black-on-white, with a refresh rate of more than 60 Hz. Floppy disks are used for message storage, providing a storage capacity of 80 kbytes on the system disk and 320 kbytes on the user disk.

Software was designed to provide maximum support for the operator. Operator – system dialogue is via keyboard and CRT screen using the menu technique. The operator need not define parameters; the system employs preset values if no other information is given. In common with the ITT 3000 teleprinter, the ITT 3150 has wordprocessing capabilities that facilitate text entry and editing.

Because the teletex service is assigned to different networks by international Administrations, communication control units had to be developed for circuit-switched and packet-switched networks, as well as the public telephone network.

User Requirements for Telecommunication Integrated Services

R. Smith
R. K. Heldman
ITT Advanced Technology Center, Shelton, Connecticut, USA

During the 1970s, telecommunication service providers and equipment manufacturers attempted to identify potential users of the ISDN. For various reasons, users did not emerge in the numbers originally envisioned. However, a new analytical methodology is helping to identify new user types more accurately, and thus to predict the kinds of services and products they are likely to require.

Methodology

The three principal factors in user type identification are working environments, operating modes, and telephony characteristics. ISDN services will be used in a broad range of environments, including banking, insurance, education, national and local government, utilities, transportation, investment, manufacturing, law, health care, wholesaling and retailing, information services, and the home.

Users in each of these environments will need services capable of operating in a variety of modes, including: interactive (inquiry/response, remote access/time sharing, graphics), data collection (polling/sensing), data distribution, remote display/documentation, transactions, video conferencing, and voice. These modes of operation can be translated into telephony characteristics, such as connect time, holding time, number of attempts, user facility network location, user error-rate tolerance, and terminal device speed. Permutation of these three factors over a range of values identified 20 distinct user types (Table 1). Each is characterized in terms of operating mode, telephony attributes, and a range of technical values.

Results

An analysis of these user types produced the following guidelines, which will influence the design of networks and products:

- For PBX and local exchange applications, many new user types will be satisfied

Table 1 – User types and possible services

User data			Range of attribute values									
Category	User type	Services	Attempts	Connect time	Holding time	Error tolerance	Data rate	Feature package	Present exchange	Present network	Future exchange	Future network
A Inquiry/ response	Type 1	Credit check	>N	N	N	H	L/H	–	SXS/elec	POTS	Elec	A/D
	Type 2	Car parts control	>N	N	N	M	M/H	–	SXS/elec	POTS	Elec	A/D
	Type 3	Airline reservations	>N	F	–	M	M/H	Yes	None	PL	Packet	A/D
B Data collection	Type 1	Retail inventory control	>N	N	<N	H	L/M	–	SXS/elec	POTS	Elec	A/D
	Type 2	Government status network	>N	F	<N	L	M/H	–	None	PL	MSG	Digital
C Data distribution	Type 1	Motel network	>N	N	<N	H	L/M	–	Elec	POTS	Elec	A/D
	Type 2	Police network	>N	F	<N	H	L/M	–	None	POTS, PL	Elec	A/D
	Type 3	Medical network	>N	N	<N	L	M/H	Yes	None	PL	Packet	Digital
	Type 4	News network	<N	F	>N	L	M/H	Yes	None	PL	NSG	Digital
D Interactive timeshare	Type 1	Remote programming	<N	N	>N	L	L/M	Yes	SXS/elec	POTS	MSG	Digital
	Type 2	Remote programming	>N	F	<N	L	M/H	Yes	None	PL	MSG	Digital
Interactive remote access	Type 1	Remote batch processing	N	N	>N	L	L/M	Yes	SXS/elec	POTS	Packet	Digital
	Type 2	Remote batch processing	>N	F	<N	L	M/H	Yes	None	PL	Packet	Digital
E Remote display/ documentation	Type 1	Facsimile	>N	N	<N	M	L/M	–	Elec	POTS, PL	MSG	Digital
	Type 2	Printing industry	>N	N	>N	M	M/H	Yes	None	PL	MSG	Digital
F Interactive graphics	Type 1	Wideband computer graphics	<N	N	>N	M	M/H	Yes	None	PL	None	Digital PL
G Transactions	Type 1	Bank network	>N	F	<N	L	L/M	Yes	None	PL	Packet	Digital
	Type 2	Stock exchange network	>N	F	<N	L	M/H	Yes	None	PL	MSG	Digital
	Type 3	Wideband users	<N	F	>N	L	M/H	Yes	None	PL	MSG	Digital
H Voice enquiry	Type 1	Reservations	>N	N	N	H	–	–	SXS/elec	POTS	SXS/elec	POTS

Attempts and holding times

- >N - greater than normal
- N - normal
- <N - less than normal

Connect time

- N - normal
- F - fast (100 to 600 ms)

Error-rate tolerance

- H - high (POTS)
- M - medium (10^{-4} to 10^{-6})
- L - low (10^{-7} to 10^{-11})

Feature package

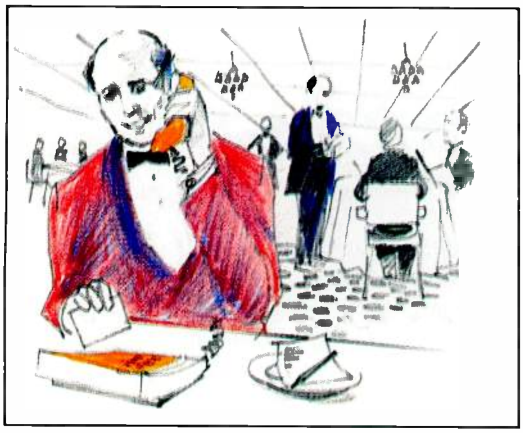
Requires conditioning or feature unique to data

Data speed

- L/M - low/medium bit rate (100 to 2400 bit s^{-1})
- M/H - medium/high bit rate (2400 to 56000 bit s^{-1})

- A/D - mixed analog and digital
- elec - electronic
- PL - private leased lines
- POTS - plain old telephone service
- MSG - message switch
- SXS - step by step

This table shows the 20 distinct user types generated by this analysis. Included in the chart are the values of the attributes for each type, references to the original category(ies), and the user type number.



(Above)
Credit checking; inquiry/response.

(Right)
Retail inventory; data collection.

with a fast connect, medium speed transaction system. The network and processors will handle an above normal number of call attempts with lower than average holding times.

- Users requiring an extremely wide band width will be more economically served using private lines until their number increases, or until videoconferencing over digital networks is available.
- An error rate or 10^{-7} will probably be acceptable for most data user types.
- Bit rates of 9600 bit s^{-1} or less will suffice for many of the new users during the first phase of their entry into the information world.
- The 64 kbit s^{-1} rate (or multiples thereof) will be sufficient for most data users during the next 10 years (1983 to 1993).
- Inquiry/response user types will be prevalent in all environments, generating single and multiple inquiries in various modes of voice, voice/data, and data communication.
- Terminals switched through PBXs and local exchanges, rather than point-to-point, will be used increasingly in industry networks to access local and remote databases.
- Translations, data collection, and data distribution with inquiry/response user types will greatly increase traffic on exchanges and facilities as retail stores change over to direct debit transactions and on-line inventory control.
- Protocols, connect times, error rates, grade of service, data tariffs, barred access, three-attempt limit, polling, retry, code conversion, multi-address calls, direct calls, short cleardown, data collection services, and so on, are features that depend heavily on an understanding of these new user types and their technical needs and requirements.

With these factors in mind, equipment designers for each of the working environments must study their market segment in detail to identify the requirements of future users, and then develop the most marketable product line.

Home communication centers and offices of the future can indeed become a reality as the ISDN is completed. There will be considerable changes in telecommunication in the 1980s; tremendous opportunities exist for perceptive equipment manufacturers and service providers.

(Below)
Medical network; data distribution.

(Right)
Print industry; remote display/documentation.

Inexpensive Digital Encryption Systems for Cordless Telephone Secrecy

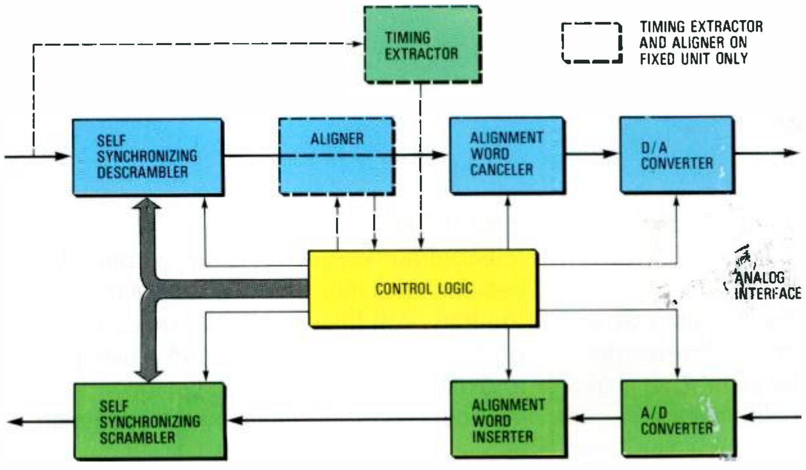
V. Baroncini
Industrie FACE Standard, Pomezia, Italy
O. Brugia
G. Campanini
W. Wolfowicz
Fondazione Ugo Bordoni, Rome, Italy

When cordless telephone sets were introduced a few years ago, customers experienced interference and loss of privacy caused by other cordless sets operating nearby on the same channels. In response to the need for countermeasures, two encryption systems have been developed, one using self-synchronizing scrambling, the other using 8B-16B cryptocoding. Both provide a high degree of security, although the second is more powerful; both utilize low cost, low power consumption LSI components. They provide a practical method for solving the problems caused by interference between cordless telephone sets.

Loss of Privacy

A cordless telephone set consists of two parts: a portable unit and a fixed unit. The portable unit contains the traditional earphone, microphone, ringer, and dial; in addition, it contains a radio transceiver that utilizes two channels, one for each direction of transmission. The fixed unit is connected directly to the subscriber link, and contains a transceiver like the one in the portable unit. Most types of cordless set use the same pair of channels for the radio connection: 1 MHz from the fixed unit to the portable unit, and 40 MHz in the other direction. Unfortunately, when the radio propagation ranges of two or more sets that employ the same channels overlap, there is a strong probability of loss of privacy, interruption of service, or charging errors.

Digital circuit for an encryption algorithm giving self-synchronizing scrambling.

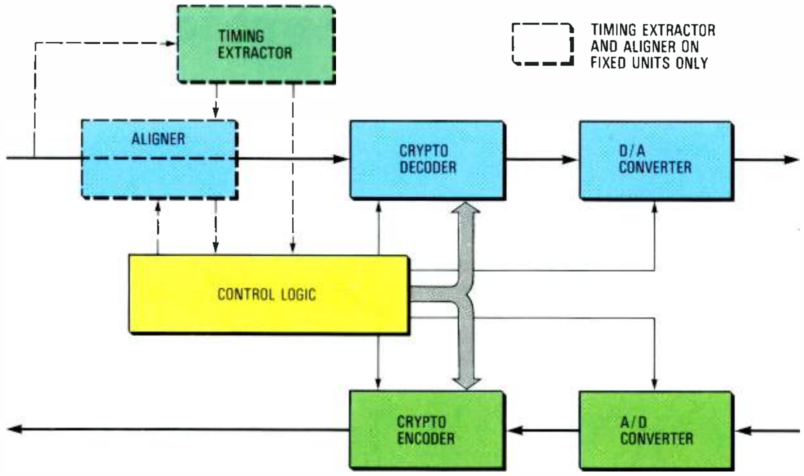


Encryption

The above occurrences can be prevented by encrypting the information passing in each direction between the fixed and the portable units. Thus each unit must be equipped with encryption and decryption devices. Encryption can be performed in two ways: on signaling messages only, or, at greater cost, on both signals and speech. Two of the less sophisticated digital encryption algorithms were selected: additive scrambling and 8-binary/16-binary (8B-16B) cryptocoding, both of which are simple and effective.

Scrambling

There are two scrambling techniques, additive and self-synchronizing. An additive scrambler behaves as a gambler who decides to take, or not take, some action depending on the toss of a coin. Mathematically speaking, the additive scrambler performs modulo-2 summation of the binary signal to be encrypted and a pseudorandom binary sequence that it generates. That is, each digit (*1* or *0*) of an input sequence is complemented (i.e. changed from *1* to *0* or vice versa) or not, according to whether the corresponding pseudorandom digit is *1* or *0*. The output sequence is unintelligible to machines that do not know the encryption key. However, a disadvantage of additive scrambling is the need to send this information in the clear to the receiving machine.



Digital circuit for an encryption algorithm giving 8B-16B cryptocoding.

In self-synchronizing scrambling, each input digit is added modulo-2 to a given combination of previously output digits; that is, the digit is complemented or not depending on whether the given combination contains an odd or even number of *1*s. Because self-synchronizing scramblers are linear in the modulo-2 algebra, the corresponding descramblers can restore the original message without requiring alignment information to be transmitted in clear.

8B-16B Cryptocoding

It is well known that linear algorithms can easily be broken by standard cryptoanalysis techniques. However, in the present application this weakness is balanced by the fact that the encryption key can be changed as frequently as necessary (e.g. after every call). Greater security can be achieved by 8B-16B cryptocoding at the price of doubling the transmission bandwidth. This algorithm can be represented as the random distribution of 8 white balls and 8 black balls into 16 cells. The 16 cells represent 16 timeslots; the white balls represent the eight digits per speech sample required in PCM transmission systems, and the black balls represent the respective complemented digits. The encryption key consists of the combination of timeslot positions chosen at random for the allocation of each digit character and its complemented version.

These encryption systems can be implemented using low cost, low power LSI components. Both provide a high degree of protection against loss of privacy because of the very large number of available encryption keys (up to $2^{16}-1 = 65535$, when using 16th order self-synchronizing scrambling, and up to $2^8 \times 8! = 10321920$, when using 8B – 16B cryptocoding) and the ease with which they can be changed.

Pragmatic Planning for the Introduction of Non-Voice Services into Existing Analog/Digital Networks

F. Casali
FACE Finanziaria, Milan, Italy
E. Lera
Standard Eléctrica Research Center, Madrid, Spain

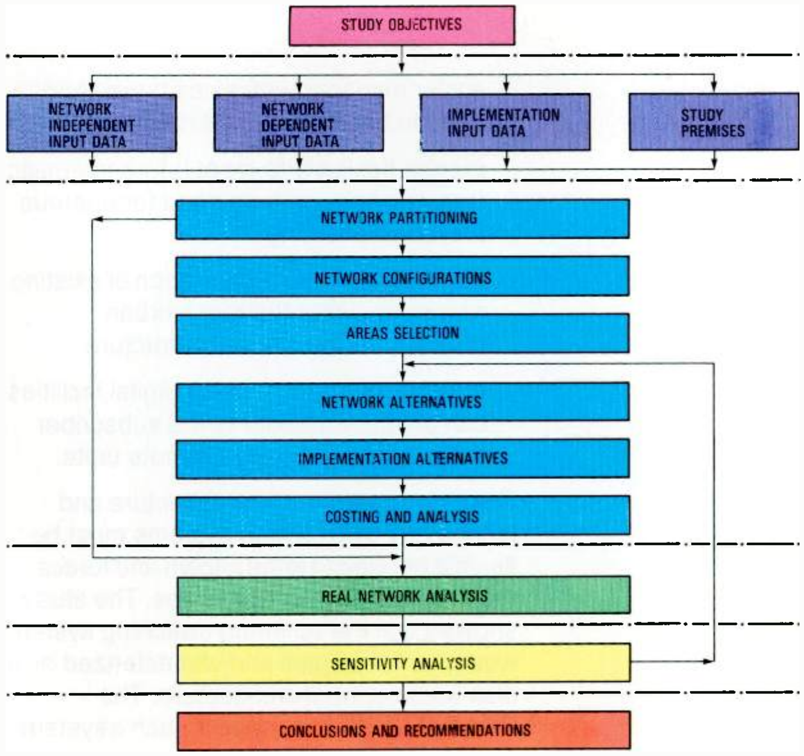
The expected rapid growth of demand for non-voice services during the next 10 to 20 years raises the problem of implementing the necessary features while the digitizing of public telephone networks (the integrated digital network or IDN) is in progress. On the assumption that the integration of voice and non-voice services in an ISDN is the ultimate goal of telecommunication evolution, a computer-assisted analytical method for optimizing the transition to such a network, using a pragmatic approach, has been developed and used in a test case to plan the introduction of non-voice services into an actual network.

Planning Method

The method represents an advance in the state of the planning art because it considers the global structure of the real network as well as the relationships between the IDN and ISDN. Various implementation strategies are postulated, then the cost of each is calculated using a flexible, modular computer program. The most effective strategy is the optimal one.

Network elements are represented by mathematical models which can be combined in various ways to represent possible network configurations. Specific values are assigned to the network-dependent parameters (subscriber loop length, number of users connected to a digital exchange, spare capacity of existing cables, etc). A set of routing patterns is established, and the dimensioning rules and costing structures of the various network equipments are considered. Overall costs and detailed costs per type of user line or per service are estimated. Sensitivity analyses can be performed, changing some of the input data according to rules established by the planner.

The method is intrinsically static; its application provides the best solution at well defined time windows (spot years), where alternatives are compared in terms of capital costs. Various possible solutions can be compared, representing different philosophies for providing non-voice services, ranging from the complete integration of voice and non-voice services to their total separation. Each alternative is implemented using different equipment, depending on the existing network and forecast IDN penetration. The computer program makes it easy to compare the dimensioning and costing implications of each solution.



Simplified methodology flowchart for network configuration planning.

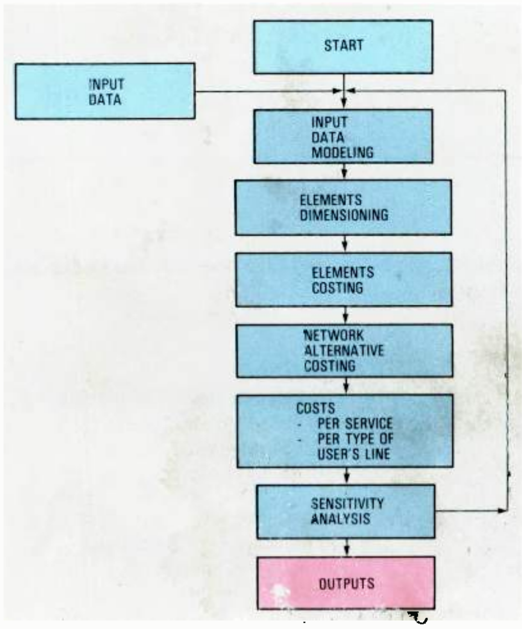
Practical Case Study

The planning method was used to study the best strategy for the introduction of non-voice services in a predominantly analog hierarchical network serving a developed region consisting of a metropolitan area, some smaller towns, and several rural areas. The areas of the region were grouped into models depending on size, traffic characteristics, subscriber density, and IDN penetration. Four user categories were considered: residential, business, public Administration, and rural. Each category was characterized by different new services requirements and traffic volumes.

The principal results of the study included the following:

Network structure: the integration of voice and non-voice services in the public switched telephone network is the most suitable long-term solution, providing:

– economy, because both voice and non-voice traffic can be carried on the same transmission facilities, and it is likely that both can share common switching facilities



General flowchart of the services network analysis program designed to help in network dimensioning and costing.

– easier management, since there is no need to handle separate networks

– greater flexibility to meet future telematic requirements, with no need for onerous additional planning

– no changes in the organization of existing networks, either the mesh urban structure or the star rural structure

– equipment savings, since digital facilities can be moved closer to the subscriber premises by the use of remote units.

Switching system: the architecture and technology of switching systems must be flexible enough to meet known and forecast requirements without penalties. The study showed that the optimum switching system would be fully digital and characterized by a distributed control architecture. The ITT 1240 Digital Exchange is such a system, providing the flexibility necessary to handle new services without major hardware or software rearrangements, and to guarantee a full application range for both voice and non-voice services. The distributed architecture of the ITT 1240 permits the small incremental addition of voice, non-voice, or combined subscriber lines. Its design is based on virtual interfaces to permit changes or additions without affecting existing functions. This will be of great importance during the IDN-ISDN transition period, when different interfaces and signaling procedures will coexist. The technology of the switching system should permit transparent switching of voice and non-voice data streams.

Implementation pattern: the availability of a full range switching system such as the ITT 1240 will make it feasible to provide new services when the demand arises, without economic penalties on existing equipment.

Editorial Offices

Enquiries relating to the different language editions of Electrical Communication should be addressed to the appropriate editor, as follows:

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