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International Standards for Telecommunications

M. B. Williams

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International standards for telecommunications

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As soon as telegraph and telephone services extended beyond local or national boundaries the need for coordination became imperative. It is not surprising that the International Telecommunications Union, the forum for world-wide cooperation, is the oldest of the inter-governmental agencies which now form the specialized agencies of the United Nations. Through the various levels at which it operates, from the plenipotentiary conference to the study groups and working parties of the consultative committees, the I.T.U. exercises a profound influence on the development and evolution of all branches of telecommunications.

Increasingly, the distinction between international and national services is diminishing and all services are coming under the direct control of individual customers and often of their machines. Intervention by specially trained operators has to be exceptional. Simplification and standardization of terminals and procedure is essential.

Other factors are operating outside the formal arena of the I.T.U. and influence the progress of standards. Manufacturing industry that looks to world markets is concerned that the purchasing specifications that define its markets should have basic compatibility; this concern is complemented by the purchasing authorities in countries without indigenous industry and who have to buy on world markets. Regional standardization may proceed faster and more deeply than world-wide standardization; this is evident in Europe where the Conference of European Telecommunications Administrations provides a natural forum and has undertaken a programme of 'harmonization' activity in cooperation with the Commission of the European Economic Community. Maintaining coherence between regional and world standardization will be an intricate but necessary task for the participants.

1. Introduction

Agreement on standards is inherent in any extension of telecommunications beyond the purely local; the history of telecommunications standards provides an insight into the evolution of telecommunications services from the early, limited, point-to-point or town exchange services through their national, international and intercontinental development to the present world-wide coverage. The paramount international organization concerned with telecommunication standards, the International Telecommunications Union (I.T.U.), is far older than those concerned with industrial standards and has established working methods and procedures that differ in several ways from the complementary organizations such as the International Organization for Standardization (I.S.O.) and the International Electro-technical Commission (I.E.C.). The basis of the I.T.U., its Convention, has the status of a treaty between sovereign states in recognition of the importance of its rôle in international relations.

This paper aims to review the history and organization of the international bodies concerned with telecommunications and to review their achievements, the programme of work that lies ahead, and their likely future. Account will be taken of the various forces that influence the rate and direction of standardization. The subject area is now so wide and so specialized in

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detail that uniform and complete coverage cannot be attempted in this paper. Instead, emphasis will be given to the topics which have been singled out for presentation by the individual contributors to the discussion meeting.

2. Evolution of the international organizations

The coming of the electric telegraph and its rapid acceptance by civil and military authorities led to the first treaty regulating cross-frontier traffic. This was concluded on 3 October 1849 between Prussia and Austria. Priorities were established; as between the countries, odd dates gave priority to messages originating in Prussia; even dates gave priority to Austria. As between classes of message, these ranked government, railway operations and the public in that order. Other European countries concluded similar bilateral treaties in the following years, and multilateral treaties followed, establishing the Austrian–German and West European Telegraph Unions. In 1865 the French Government, playing the catalytic rôle in international relations which has so often laid the foundations of international agreement, invited representatives of the major countries to Paris leading to the establishment of the International Telegraph Union and to the signing, by 20 delegations, of the first International Telegraph Convention on 17 May. The United Kingdom was not then eligible for membership of this body since, unlike the rest of Europe, its telegraph services were not under the control of the state. In 1871 the U.K. telegraph services were nationalized and the U.K. qualified for membership of the I.T.U. Four years later, private operating companies were admitted to participate in technical and operational conferences. An enduring legal framework for regulating international telecommunications had been established by the International Telegraph Convention of 1865 and little difficulty was found in incorporating regulations for telephony and radiocommunication at later stages. The distinction between governments and operating agencies has, to this day, been a paradox in the day-to-day working of the Union and its specialized committees. Over the years, compromises have been worked out to enable governments, operating companies and manufacturers to make appropriate contributions to the advancement of telecommunications. However, North America, where the bulk of telecommunications services are operated by privately financed companies, has always retained its freedom of action and, for example, U.S.A. is not a signatory to the telephone regulations. The three largest telephone systems of the world, those of U.S.A., Japan and the U.K. are, technically, in the hands of 'recognized private operating agencies' and have no standing, in their own right, at the governing level of the I.T.U. or its Consultative Committees.

Within the U.S.A. there is a long tradition of establishing industry standards through the lead given by the principal companies in a particular field. For telephony, this tradition began soon after commercial exploitation of the telephone with cable and switchboard conferences among the American Bell Companies and was consolidated through Bell System Standards and the dominant manufacturing position of the Western Electric Company. In 1925 the overseas activities of Western Electric were ended but the company's standards had strong influences outside North America. This is illustrated by the transmission performance specification, incorporated in 1905 in the agreement between the National Telephone Company and the British Post Office, which was based on the American Telephone and Telegraph Company's standard test circuits and unit of assessment (mile of standard cable), shown in figure 1. All the components in the test circuit were defined as Western Electric Company types.

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Moreover, the realization of the benefits of unity of control as exercised since 1900 by the Department of Long Distance of A.T. and T. undoubtedly influenced Sir Frank Gill, then Chief Engineer of the Western Electric Company of London, in his plea for an effective European organization to deal with 'through telephone service'. In his Presidential address to the Institution of Electrical Engineers on 2 November 1922 he proposed the calling of a conference of European telephone authorities, as a temporary alternative to the 'unity of control' that he

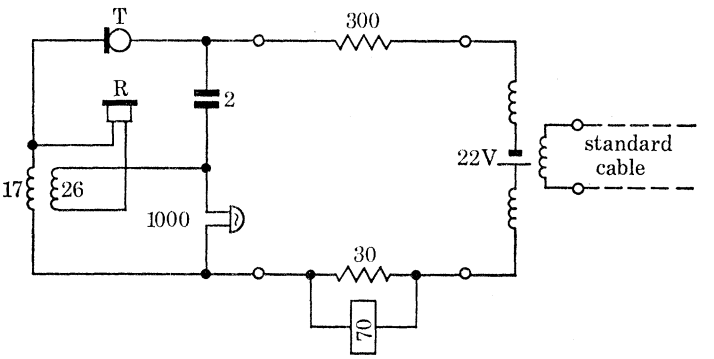

FIGURE 1. Transmission test circuit adopted in 1904 by National Telephone Company and General Post Office.

advocated. Such a conference was held in Paris in 1923 and led to the formation of the International Consultative Committee for Long-Distance Telephony (C.C.I.F.) (Valensi 1929) for 'the study of standards regulating technical and operating questions for international long-distance telephony'. Sir Frank Gill's view, that unity of control was necessary and could only be achieved through a European long-lines agency, was not adopted and so the separate operating authorities in Europe and later on in other continents had to learn to cooperate and to run increasingly complex systems by consensus. It may be that the principles of cooperation established in the early years were a necessary foundation for the growth of global telecommunications after 1955. In 1925 this committee and a newly formed similar committee for telegraphy (C.C.I.T.) became an integral part of I.T.U. with the tasks of studying and formulating Recommendations on technical and operating topics in their respective fields.

The use of the term 'Recommendation' in contrast with 'Regulation' correctly implies the non-mandatory nature of the technical agreements reached by the consultative committees. Indeed, the long life and large investments involved in telecommunications equipment, the differing practices and rates of development among various countries, indicate no other possible way of proceeding with the definition of new techniques and of invoking the necessary compromises.

Significant stages in the formal evolution of the I.T.U. and its consultative committees may, then, be briefly summarized by the following significant dates:

1865	Paris	I.T.U. established by 20 European States.
1903	London	15 articles on international telephony agreed.
1923	Paris	C.C.I.F. established for study of long-distance telephony.
1925	—	C.C.I.T. established for technical study of telegraphy and with C.C.I.F. to become an integral part of I.T.U.
1932	Madrid	International telegraph and radiotelegraph conferences combined to form International Telecommunications Union.

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1927	Washington	C.C.I.R. formed.
1947	Atlantic City	I.T.U. recognized as the specialized agency for telecommunications of United Nations.
1956	Geneva	C.C.I.F. and C.C.I.T. combined to form C.C.I.T.T.

The structure and organization of the I.T.U. and the Consultative Committees was sufficiently well established by the mid-1950s to respond efficiently to political and technical change. The most significant of these changes were the transformation of colonial territories into independent states so that membership of the I.T.U. expanded from 73 in 1947 to 148 in 1975, the explosive growth in international telecommunications following the provision of intercontinental telephone communications via submarine cable and satellite links and the emergence of digital communications as a viable technology. Technical discussions in the Study Groups now involve a much wider spread of participation than was customary two decades ago and reflects the increased need for national developments to keep in step with one another as international procedures move down to the level of the individual subscriber.

The Study Groups of the C.C.I.T.T. (17) and the C.C.I.R. (11), plus 3 joint Study Groups have evolved over many years. They represent both a continuity with the foundation of the Consultative Committees and a series of responses to advances in technology and in operational needs. It is convenient to identify them grouped as in table 1.

TABLE 1

C.C.I.T.T. Study Groups	
operational recommendations	
including service quality, tariffs and maintenance	I, II, III, IV
technical recommendations	
telegraphy, telex and facsimile	VIII, IX, X, XIV
telephone switching and signalling	XI
telephone transmission and networks	XII, XVI
transmission systems	XV
data communications	VII, XVII
digital systems and networks	XVIII
electrical and mechanical protection	V, VI
planning new national networks	
transmission, economics and switching	G.A.S. 3, 5 and 6
C.C.I.R. Study Groups	
propagation, space research, standard frequencies	1, 2, 5, 6, 7
radio-relay and communication satellites	9, 4
fixed and mobile services	3, 8
broadcasting	10, 11
joint C.C.I.R./C.C.I.T.T. Study Groups	
sound and television transmission	C.M.T.T.
noise and availability	C.M.B.D.
vocabulary	C.M.V.

3. C.C.I.T.T. STUDY GROUPS

(*a*) *Digital systems and networks*

The introduction of time-division switching and signalling and pulse-code modulation (p.c.m.) in telephony, taken in conjunction with studies in the use of similar techniques for other services (data, television, etc.) led the Plenary Assembly of the C.C.I.T.T., in 1964, to create a special study group (now known as Study Group XVIII) responsible for initial studies of all problems associated with digital systems and networks.

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In its early days, the Study Group was concerned principally with establishing parameters for p.c.m. telephony and eventually recognized two alternative systems (see figure 2):

North American: 24 channel system, using μ-law encoder and a gross digit rate of 1.544 Mbit/s. Higher order levels defined at 6.312 Mbit/s and 32.064 Mbit/s or 44.736 Mbit/s.

European: 30 channel system, using A-law encoder and a gross digit rate of 2.048 Mbit/s. Higher order levels defined at 8.448, 34.368 (optional) and 139.264 Mbit/s.

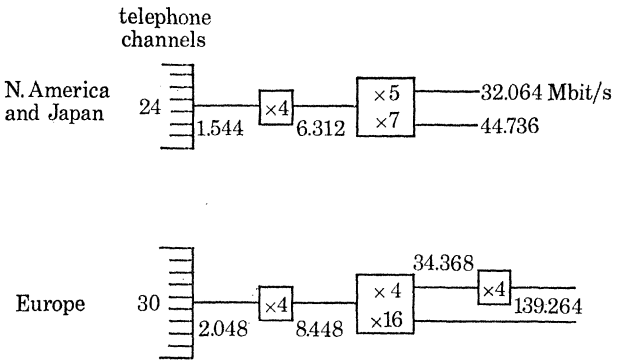

FIGURE 2. Alternative digital hierarchies recommended by the C.C.I.T.T.

These systems are incompatible at all levels although it has been agreed that international digital paths will assume that A-law encoding will be used. It cannot be denied that the divergence of basic digital standards is unfortunate and is likely to pose continuing problems as the two continents develop digital networks. Really serious long term problems can be foreseen if other countries feel free to choose either system according to short term national needs. Study of digital systems and networks in C.C.I.T.T. reflects the different emphasis on digital switching; in North America primary interest is in digital switching in the existing analogue environment; in Europe digital switching is seen as integrated with digital transmission to form digital networks. Consequently, study of digital networks by Study Group XVIII is being carried forward primarily for the 64–2048–8448 kbit/s (30 channel) hierarchy.

The programme for Study Group XVIII is primarily concerned with defining interfaces and objectives so that development of systems can proceed with the assurance of eventual interworking, taking account of the inevitable long transitional period while present analogue and future digital systems coexist.

In its approach, therefore, Study Group XVIII has to consider the following principal subject areas:

(i) overall aspects of digital switching, signalling and transmission, forming an integrated digital network for telephony (i.d.n.);

(ii) integration of digital services to form an integrated services digital network (i.s.d.n.);

(iii) characteristics and performance of digital transmission systems on cables, waveguides and optical fibres; associated multiplexes and encoders;

(iv) synchronization of digital networks;

(v) definitions.

Under (i), hypothetical reference connections and digital paths will be studied (figure 3). These will be used as a basis for deriving recommendations for performance objectives for all elements of digital networks. e.g. jitter, error rate, interference, slip and delay. It seems likely

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that considerable work will be involved in drawing up objectives for error rate that are applicable to individual system design problems.

Closely associated with the concept of digital networks is Study Group VII, responsible for public data networks, since it is now generally accepted that synchronous digital data services will be derived from the 64 kbit/s digital path corresponding to a single speech channel and will share the inter-exchange common-channel signalling systems being defined by Study Group XI. The work of Study Group VII extends down to the interface with the subscriber in the national network and thus involves the interests and expertise of the computer industry and Technical Committee 97 of I.S.O. Participation in the work of Study Group VII by computer interests and I.S.O. and cross-representation at technical meetings has been a feature of these studies and this collaboration must continue if real progress towards public data networks is to be achieved.

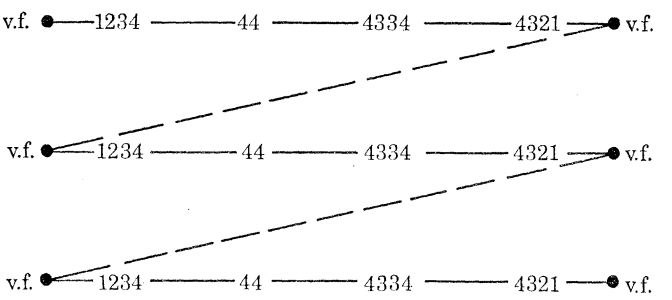

FIGURE 3. 2500 km hypothetical reference digital path recommended by the C.C.I.T.T. for 139.264 Mbit/s digital line systems: v.f., voice-frequency connection; 1, 2, 3, 4 are the first, second, third and fourth levels of multiplexing.

(*b*) *Telephone switching and signalling*

C.C.I.T.T. Study Group XI is involved in some of the most complex and far reaching of the technical advances in telecommunications. The major aspects in this field are the general introduction of stored program control (s.p.c.) of switching systems, already well established in North America, and the evolution of digital switching and signalling. S.p.c. itself is too complex for international standardization in the foreseeable future but aspects of its introduction are being actively pursued. These include design of a specification and description language (s.d.l.) for s.p.c. telephone exchanges and of a high-level programming language and a related man–machine language for the stored program control system itself. These studies are aimed at simplifying the procurement, design and maintenance of future exchanges irrespective of differences in detail design of the switching systems. An interesting aspect of s.d.l. is the evolution of 'state' pictures (figure 4) with pictorial elements, for use in the specification of call-handling processing. The man–machine language will be applicable in international network operation and maintenances. The high-level language work has now reached the stage of a draft manual which will form the basis for a future C.C.I.T.T. Recommendation. Following the guidelines set by Study Group XVIII for digital networks, Study Group XI has begun to draft Recommendations for the switching and transmission characteristics of a digital exchange suitable for handling either 2.048 or 1.544 Mbit/s digital streams, corresponding to 30 or 24 channel p.c.m. telephony respectively. These recommendations will include requirements for transmission delay, error rate, jitter and slip and will set objectives for call set-up time.

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Complementary to this work is the study and definition of high-speed common-channel signalling (using 64 kbit/s digital links) operating directly between the control systems of exchanges in a network. The system now under study will be able to serve different dedicated services (e.g. telephony, telex, data) and eventually to form part of an Integrated Service Digital Network.

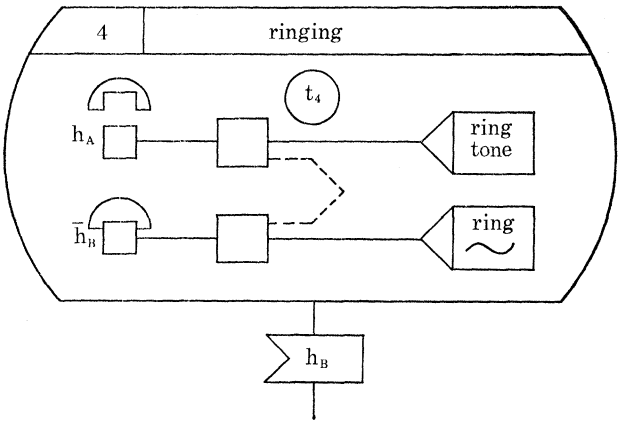

FIGURE 4. Typical use of state picture in the specification of call-handling processing.

(*c*) *Transmission*

The study of transmission performance and transmission systems by C.C.I.T.T. represents a continuing programme since the inception of the C.C.I.F. Study Groups XII and XVI work closely together in determining the overall performance requirements for telephony and corresponding network planning rules. Hitherto, laborious subjective testing techniques have been required from which objective planning criteria are derived. Much information on human telephoning behaviour has now been collected so that future assessment of transmission performance can largely be reduced to calculation and modelling. For the future, account has to be taken of the eventual introduction of radically new types of telephone instrument, of changes in the local network and of the emergence of integrated digital networks.

Study Group XV has, hitherto, been concerned solely with analogue (frequency-division) transmission systems. At present, the performance characteristics of digital transmission systems carried on physical media are studied by Study Group XVIII because it is not yet possible to define digital performance characteristics independently of the digital network. Study Group XV is, however, beginning to study the requirements for digital transmission over cables and to consider the physical characteristics of new media that will use digital transmission such as millimetric waveguide and optical fibre. It is unlikely to make rapid progress with either of the last two in view of the early stage of the technique and uncertainties on their rôle in national or international networks.

(*d*) *Vocabulary*

An essential part of international discussions and hence of specification and standards work is agreement on the terms, definitions and symbols which are to be used. Such agreement forms a basis for technical Recommendations and day-to-day operating dialogues. For many years the I.T.U. has published a multi-language 'yellow book' in which corresponding terms in several languages are set out and defined. With the introduction of new technologies and their application in several fields, two problems have been encountered. Specialists working on new

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technologies need to reach rapid agreement on terminology and for this agreement to be made known widely and quickly. New editions of the 'yellow book' cannot be produced as soon as needed. Moreover, many new concepts in, for example, digital electronics ought not to be defined solely in the context of initial use. In order to deal with these problems, terminology is considered at several levels.

Within individual Study Groups of C.C.I.T.T. and C.C.I.R. it is now customary to appoint rapporteurs for terminology who strive to obtain, in the working languages, adequate definition of new terms as they arise in particular study areas. Lists of such terms appear in the reports of the Study Groups and are used and defined in Recommendations as necessary.

Longer term rationalization of terminology is, in effect, entrusted to a joint group of representatives of C.C.I.R., C.C.I.T.T. and the International Electro-technical Committee (I.E.C.) for incorporation in the International Electro-technical Vocabulary which may eventually replace the 'yellow book'. A process of stage-by-stage widening of the scope of discussions on new terms takes place in which the definitions are revised to reflect the wider usage of the C.C.I.T.T., the C.C.I.R. and the general electro-technical community. This is inevitably a long process, extending over many years before formal publication of additions to the I.E.V. For practical reasons, telecommunications terms and definitions will often become established with the form and status given them by use in the technical group where they are introduced. Recognition of this fact has induced the C.C.I.T.T. to assign responsibility for terms and definitions to the Study Group rapporteurs and for them, in conjunction with the Secretariat, to carry on discussions at the various levels until agreement is reached within I.T.U. and with I.E.C.

(*e*) *Maintenance*

For many years the study of maintenance by the C.C.I.T.T. Study Group IV has concentrated on the transmission characteristics of telephone circuits and wide-band links in the international network. In the course of this work specifications have been prepared for instruments for measuring various parameters. These include quantizing distortion of p.c.m. channels, and impulse noise and bit-error-rate of digital links. For the future, this work will be extended to include instruments for measuring characteristics of interest to non-telephonic signals (transient phase and gain disturbances) and extending the scope for measuring on digital links (e.g. for code violations). Automatic measuring equipment for telephony, sound programme and television circuits is now becoming practicable, and specifications exist or are being prepared for measuring transmission and signalling characteristics.

Broader studies include, for the future, a new approach to a general maintenance organization and studies of performance of the international telephone network as disclosed by test calls.

4. C.C.I.R. STUDIES

The activities in C.C.I.R. of particular interest for the present paper concern C.C.I.R. Study Group 9 (radio relay systems) and Study Group 4 (communication-satellite systems).

Radio relay system development has been brought to a high degree of standardization so far as concerns the transmission of analogue signals, i.e. television and frequency division multiplex of telephony and other services that use telephone-type channels. Radio frequency channelling plans have been recommended for the fixed point-to-point services in the (nominal) 2, 4, 6, 8 and 11 GHz bands; technical characteristics and overall performance are recommended as a

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basis for specification. An important aspect in the evolution of the recommendations has been the definition of hypothetical reference circuits as a means for specifying circuit noise objectives. These objectives can be used to determine certain factors in equipment design and the planning of radio relay links to take account of the varying characteristics of the radio paths. Variations in path attenuation can be translated directly into variations in circuit noise and correlated with objectives for the various services to be carried on the radio relay system. Close cooperation has been maintained for many years between the Study Groups concerned with line transmission in the C.C.I.T.T. and those concerned with microwave radio transmission in the C.C.I.R. The aim of this collaboration has been to define transmission paths to meet comparable performance objectives irrespective of the media used. This work has been focused on the C.C.I.R./C.C.I.T.T. Joint Study Group Special C (recently redesignated C.M.B.D.).

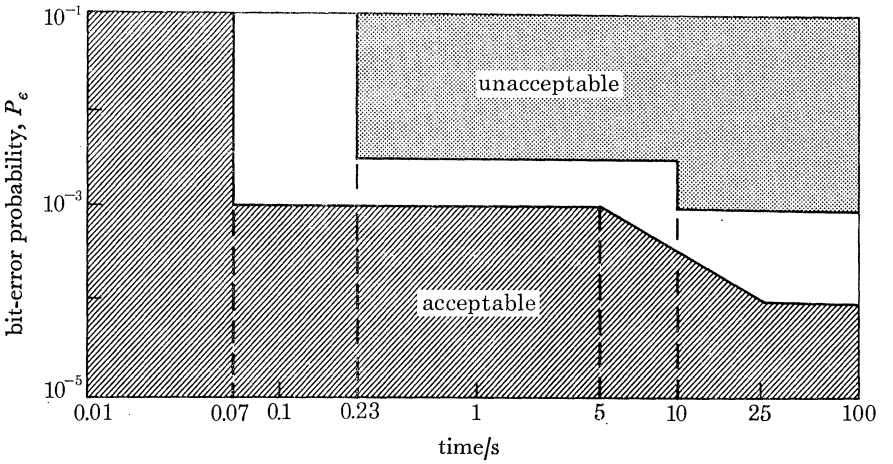

FIGURE 5. Proposed objectives for the duration of error bursts and probability of bit errors.

Future development of microwave systems and hence future activities of Study Group 9 are likely to be concentrated on two aspects. Higher radio frequency bands, above about 11 GHz, are likely to come increasingly into use and the problems associated with exploiting these new bands will need to be identified and made the subject of Recommendations. The other aspect of work for Study Group 9 will concern the technical and performance characteristics of digital radio relay systems for use in all frequency bands above 2 GHz including those at present used for analogue transmission. These new radio relay systems will be required to carry p.c.m. telephone channels assembled by time division multiplexing, coded analogue signals such as television and other signals such as data and telegraphy which are essentially originated in a digital form. The C.C.I.R. has already recommended the use of identical frequency plans in the 2–8 GHz bands for either analogue or digital use.

The 11–13 GHz frequency band is at present used either for analogue or digital signals but there is general agreement that use of the bands above about 17 GHz should be standardized for digital use only.

As mentioned earlier a digital hierarchy and several 2500 km hypothetical reference digital paths (h.r.d.p.) have been defined by C.C.I.T.T. Study Group XVIII for the design of digital ransmission systems on any medium. A major problem for C.C.I.R. Study Group 9 will be establishing recommendations to take account of the effects of short variations in path attenuation on digitally multiplexed signals. These effects could be much more serious than on

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frequency multiplexed signals since, in time division systems, multiplex synchronizing signals are associated with the multiplex signal itself and could be so corrupted by digital errors during deep fading conditions that synchronization is lost.

Two lines of study consequently need to be pursued in the coming study periods. First, C.C.I.R. Study Group 9 will need to study variation in the propagation characteristics of radio paths and to deduce the corresponding error rate characteristics for the h.r.d.p. Previous research work on radio link fading has been based on the needs of f.d.m. systems with the use of measuring instruments characterized by an integrating time of one second or one minute; for the study programs for digital radio relay links much shorter times will be significant corresponding to short and deep Rayleigh fading. This represents fundamental work in a new field. It is likely that this kind of fading will be more prevalent in the long links that are typical of the lower frequency bands (2, 4 or 6 GHz) than in the higher frequency bands above 11 GHz.

From consideration of the error rate characteristics on the h.r.d.p., Study Group XVIII of the C.C.I.T.T. will need to establish design objectives which recognize the duration of error bursts, the nature of the error bursts and the interval between them. Figure 5 gives some initial proposals for these objectives.

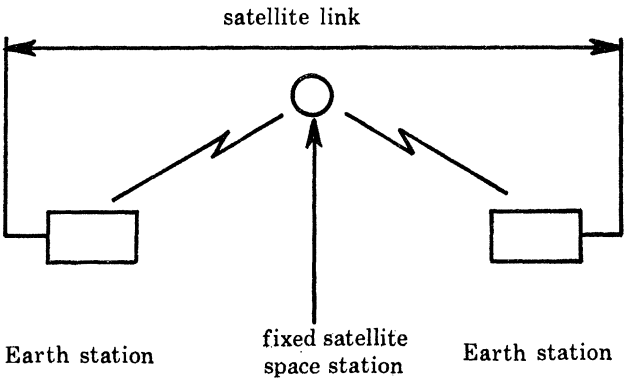

FIGURE 6. Hypothetical reference circuit recommended by the C.C.I.R. for a communications satellite.

Communications satellite systems

Study Group 4 of the C.C.I.R. began to study communications satellite systems following the 9th Plenary Assembly at Los Angeles in 1959. An Extraordinary Administrative Radio Conference, in 1963, established radio frequency spectrum allocations and administrative procedures for communications satellites. These activities set the scene for the rapid technical and commercial development of space communications. The advances in intercontinental telephony following the introduction of high capacity deep-sea submarine cables had already led the C.C.I.T.T. to establish Recommendations for world-wide transmission and network planning. However, the special features of communication satellite systems required the following new aspects to be considered:

(i) Geostationary satellites introduce a transmission delay of about 260 ms per hop in each direction. This places severe demands on echo suppression and network operation since the effects of the delay introduced by more than one hop may not be tolerable.

(ii) Satellite links are relatively independent of geographical and political boundaries and as simple a hypothetical reference circuit as figure 6 is sufficient for specifying performance.

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Telephony and television performances on such a circuit are similar to those recommended for intercontinental cable circuits. Moreover, relatively remote countries, particularly developing countries, have become connected to the international automatic telephone network long before terrestrial links (other than h.f. radio) would have been extended to their frontiers. As a result, many long links have been set up connecting remote international transit centres and increasing the reticulation of the international network. Such countries have been drawn quickly into the problems of international operation and introduced to the need for disciplines and standards. Similarly, the prospect of maritime satellite systems promises to involve individual ships in the operation of the international network.

An important rôle of C.C.I.R. is concerned with problems of interference. Its earlier studies, now mainly completed in cooperation with Study Group 9, were to determine criteria by which terrestrial and satellite services could share the same frequency bands. This work involved reaching agreement on power limits for both services, acceptable interference quotas and some guiding rules on the siting of Earth stations. A much more complex task, now in progress, is to find ways of keeping interference between satellites within acceptable limits while allowing scope for the development of new services (such as domestic telecommunications and broadcasting services, especially those using small Earth stations) and efficient exploitation of the limited resource represented by the geostationary orbit. These studies will involve consideration of means of achieving high technical performance from future satellites, such as good suppression of aerial side-lobe response at Earth stations and on satellites; efficient dispersal of carrier energy; precise control of satellite orbit and attitude; and improved coordination in the use of the frequency spectrum.

International coordination of technical standards for satellite communications is not only effected by C.C.I.R. Study Group 4 but also by international operating agencies and, in particular, Intelsat. Intelsat determines many of the basic technical characteristics of the Earth stations that use its satellites, partly to give economy in the use of the space segment and savings in the costs of Earth stations and partly because use of the common highway provided by a satellite can only operate successfully if all the participating Earth stations follow common rules. The need for detailed technical standardization becomes more pressing as multiple-access systems come into more general use.

Machinery for the coordination of operational geostationary satellites was agreed by the World Administrative Radio Conference (W.A.R.C.) in 1971; in essence, the I.T.U. receives provisional characteristics of new systems sufficiently in advance of the launch of a satellite to permit circulation and study by others who may be affected. Agreed characteristics are eventually recorded by the I.F.R.B. A forthcoming W.A.R.C., planned for 1979, will review these administrative arrangements and be able to introduce improved and simplified procedures, possibly by adopting technical guidelines suggested by C.C.I.R., which will minimize the work of consultation and negotiation.

5. The interests and influence of the developing countries

Since 1947 the number of independent countries forming the I.T.U. has doubled so that the developing countries of the world represent 80 % of the membership. Telecommunications is a key factor in the development of any country; the need for I.T.U. to consider the needs of the developing countries is now recognized in the Convention. Technical assistance is implemented

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through the organization of the I.T.U. and the I.T.U. participates in the United Nations Development Programme.

In 1960 the I.T.U. set up a Technical Co-operation Department with the responsibility of rendering short term assistance to developing countries. This may take the form of seminars on telecommunications topics such as planning and maintenance or arranging for experts to assist in planning and training. Successive Plenary Assemblies of the C.C.I.T.T. have responded to the increasing participation of the I.T.U. membership (120 countries were represented at the 1976 Assembly) by identifying specific elements of the study programmes as contributing to the needs of developing countries. One way of achieving this aim has been for certain Study Groups to include questions of particular relevance to new networks in non-industrial countries in their study programmes. In past years this resulted in the preparation of manuals on automatic telephone networks, on planning open-wire lines and on certain basic constructional topics. Since 1964 the preparation of new technical manuals has been entrusted to Special Autonomous Groups (G.A.S.) (Chapuis 1972) functioning outside the normal Study Group structure. These groups have undertaken the preparation of manuals on the following subjects:

G.A.S. 1	1965, 1968	basic planning, choice of switching equipment
G.A.S. 2	1968	local telephone networks
G.A.S. 3	1970	economic and technical factors in the choice of transmission systems
	1977	rural telecommunications
	1980	general network planning (including satellite and p.c.m. systems)
G.A.S. 4	1970	primary sources of energy
G.A.S. 5	1968, 1972	economic studies at the national level
G.A.S. 6	1980	economic and technical aspects of the choice of switching systems

Extension and updating of the G.A.S. manuals is now entrusted to the appropriate Study Group. Study Groups XII and XVI are dealing with additions to the telephone network manuals prepared by G.A.S. 1 and G.A.S. 2; this will form a manual for 'Transmission Planning for Switched Telephone Networks'. An important complement to the work of the new Group, G.A.S. 6, is a new question entrusted to Study Group XI by the 1976 Plenary Assembly aimed at drafting Recommendations on the choice and standardization of automatic switching equipment for use in national networks. The scope of this question, in practice, remains to be worked out by the Study Group. There is no previous experience of undertaking international studies of such complex matters as switching systems. It is clear that this work goes far beyond the traditional rôle of the C.C.I.T.T. in establishing the basis for international interworking.

These activities could make a significant contribution to telecommunications standardization by ensuring that the expansion beyond the limits of the industrialized nations of today will follow a coherent pattern and so ensure interworking with the existing networks. In effect, the I.T.U. is filling the gap left by the withdrawal of the franchised operating companies or the colonial powers who introduced and maintained their native standards and practices in foreign territories.

Other consequences can be foreseen from the exposure of operating and manufacturing interests from the industrial countries to the needs of the developing countries and to the comparison of alternative practices in the manuals produced by the C.C.I.T.T. This is likely to result in the gradual narrowing of the range of options and divergences among national practices. Furthermore, it is possible that the large potential market of the developing countries

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(particularly where joint planning and implementation organizations, such as Citel in South America or Panaftel in Africa, establish common specifications) may effectively standardize certain types of equipment. As a result the characteristics of the markets of the developing countries may reflect back into the networks of the industrial countries so that home and export versions of equipment become similar.

The involvement of developing countries in the evolution of telecommunications standards may be contrasted with the relative lack of influence of these countries in industrial standards coordinated by I.S.O. and I.E.C. Membership of those organizations (which do not have the special relationship with the United Nations that is a feature of the I.T.U.) is mainly confined to the industrialized nations which already have national standards institutes. The I.T.U. may well have established a pattern of cooperation that other organizations will follow in due course.

6. C.E.P.T.

(*a*) *Organization*

Although the I.T.U. is the supreme authority for the world-wide coordination of telecommunications, there is need and opportunity for collaboration among regional groups. Where geographical, social and economic differences are lessened it should be possible to reach agreement in greater depth or perhaps on topics inappropriate to a world-wide body.

New bodies have come into existence to cover interests of particular regions. The Conférence Européenne des Administrations des Postes et des Télécommunications (C.E.P.T.) was formed in 1958 and now has 26 members, representing the Administrations of Western Europe from Iceland to Turkey. It is governed by a biennial Plenary Assembly and a permanent committee each for posts and telecommunications. Although C.E.P.T. was initially concerned principally with tariff and broad operational matters it has increasingly moved into technical areas and its study program now parallels some of the activities of C.C.I.T.T. and C.C.I.R.

C.E.P.T. is organized in Working Groups in the following way:

subject area	working group
operations and tariffs	Tg, Tp and PGT
radiocommunications	R
sound and television transmission	TTVS
services and facilities	SF
long term studies	ELT
data communications	CD
switching and signalling	CS
transmission	TR

Additionally, four coordination groups (CCTS, CLTA, CSTD, CSH) have special responsibilities for satellites, trans-Atlantic services, data transmission and harmonization.

(*b*) *Harmonization*

The Working Groups concerned with standardization are primarily SF, CD, CS and TR; additionally, Working Group R is concerned with mobile radio and maritime radio services and techniques. The activities of these Groups have been gradually evolving but their study programs are now being influenced by the concept of 'harmonization', as the Commission of the European Economic Community (E.E.C.) develops and interprets its mandate under Article 100 of The Treaty of Rome. The Council of Ministers of the E.E.C. countries

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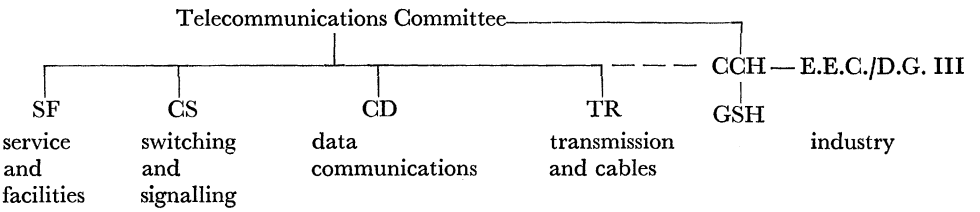
adopted a resolution on industrial policy on 17 December 1973 which included a timetable for the first stage of the programme for the elimination of tariff barriers through harmonization of national standards and the establishment of European Standards. Consultations between the Commission and interested parties in the nine member states began in 1974 on the question of including telecommunications equipment within the ambit of a draft Directive aimed at opening the markets for public sector purchasing to cross-frontier trade. It was recognized that telecommunications presented special features so that harmonization could not usefully be pursued solely within the boundaries of the E.E.C.; there were already long-standing and well established procedures for coordination among all the countries of Europe through C.E.P.T. and with countries in other continents through C.C.I.T.T. and C.C.I.R.

Moreover, there was growing realization by telecommunications authorities that the rapid advances in technology were opening up options likely to lead to divergences in services and facilities and in the technical detail of the design of new equipment. Such divergences, in addition to the demands on manpower which they represented, could lead to long term incompatibilities which could hamper interworking between countries in the future. These arguments led to the conclusion that the harmonization of national specifications was likely to be beneficial to the orderly evolution of telecommunications and was, in any case, a natural extension of the study programmes of C.C.I.R. and C.C.I.T.T. C.E.P.T. was the obvious body to organize a harmonization programme in collaboration with the E.E.C. Commission and, following agreement in principle to this course being given by the 8th Plenary Assembly of C.E.P.T. (Torremolinos, 1975), certain organizational changes were made by the Telecommunications Committee and came into being during 1976. These are summarized in the following chart:



Working Groups come under the general direction of a Coordinating Committee for Harmonization (CCH) which is itself supported by a special group concerned with the detail of the harmonization studies. Liaison with the E.E.C. Commission is achieved by periodical exchange of correspondence between the Chairman of CCH and Director-General III in the Commission.

The Working Groups work closely in line with the corresponding C.C.I.T.T. Study Groups, generally aiming to speed up the resolution of differences and uncertainties by the quicker and less formal interaction that is possible within Europe. They aim to achieve a higher level of rationalization while remaining within the more general recommendations laid down for worldwide agreement by C.C.I.T.T. The necessary close relationship of the C.C.I.T.T. and C.E.P.T. studies is ensured by common membership by the specialists in the corresponding Groups and Working Parties, and by inviting members of the C.C.I.T.T. Secretariat to attend meetings of the Working Groups.

The Coordinating Committee for Harmonization has laid down a basis for harmonization studies to be pursued by the specialized working groups. This includes a statement of the

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objectives and principles, the primary area of technology to be tackled and the criteria to be adopted when addressing the appropriateness of a particular topic for study.

Preliminary examination of possible study programmes has shown the need for a clear definition of the level to which system harmonization is being applied. Three levels of harmonization have been identified and a current task of the Coordination Committee is to define these levels so that all Working Groups are operating uniformly. A simple definition of these levels is as follows: Level 1, interworking capability; Level 2, functional interchangeability; Level 3, equipment interchangeability. It is recognized that Level 1 corresponds to the well established pattern for the formulation of C.C.I.T.T.–C.C.I.R. recommendations. Clearly, work at this level lays the foundations for international telecommunications and must be maintained. Level 2 represents the main thrust for the harmonization programme since most systems and equipment can be defined in functional terms for the purpose of preparing purchasing specifications which will ensure uniformity of services and facilities. A current proposal is for elimination in Europe of options within the C.C.I.T.T. recommendations.

The third level of harmonization, leading to full mechanical and electrical standardization, represent an aim for these operating authorities that import from world markets and may reflect strong pressures from export markets. Nevertheless, within Europe there are several substantial national manufacturing industries for telecommunications, each linked through decades of cooperation with its national telecommunications authority, and it is unrealistic to suppose that wide agreement on the approach to the third level will be achieved easily or, even without external pressures. This level, moreover, brings into question industrial property rights, patents, copyright and licensing aspects and will be of major importance as industry becomes involved in it.

The areas of technology to be studied in the context of harmonization are largely identified with the terms of reference of the Working Groups as now constituted; these are reviewed in more detail in succeeding paragraphs. However, certain basic topics have been reserved for preliminary examination within the Special Harmonization Group (GSH). These topics include network structure, quality assurance and quality of service.

(*c*) *Services and Facilities Working Group* (*SF*)

The work of SF has been largely motivated by the general desire of the C.E.P.T. Administrations to move towards more uniformity in the customers' services in Europe. Initially the scope of the Group was confined to the telephone service and the emphasis was on new services but the harmonization programme proposed by the Group now covers data and other non-telephonic services as well as the telephonic services.

Harmonization of services offered to subscribers is probably the most fruitful aspect for early study. Some progress over a wide range of services is necessary before significant progress above Level 1 can be made in most aspects of system and equipment harmonization.

The programme that the SF Working Group is proposing to undertake, including harmonization aspects, may be summarized as follows:

(i) *Telephony*

services and facilities in p.a.b.x.;
future requirements for coin boxes and for video telephony;
functional requirements for setting-up and clearing-down calls;

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supplementary services (and charging) in telephone exchanges;
quality of service (users' and operational requirements);
functional requirements for equipment at subscribers' premises;
facilities for special classes of user (e.g. handicapped, police, etc.);
operational control procedures;
functional requirements for mobile radio services (in cooperation with the Radio-Communication Working Group).

(ii) *Data communications and other non-telephonic services*

essential and additional facilities on public data services; possible new teletype services;
data facilities to be provided by a public message-switching service;
essential and desirable features for facsimile machines;
procedures and requirements for approval of private attachments to public networks;
directories, numbering plans and operating procedures for public data services.

(*d*) *Switching and Signalling Working Group* (*CS*)

The programme of CS is closely linked with that of C.C.I.T.T. Study Group XI and, like that group, is extending its field from signalling systems to embrace the wider aspects of switching. Existing switching systems are closely associated with particular manufacturers' concepts and practices and these in turn with individual operating authorities' practices, so that there is little scope for harmonization above that of the services and facilities offered and signalling. Harmonization of switching systems must, therefore, begin with the introduction of new techniques and new concepts; for example, the first stage of harmonization at the periphery of a digital network will aim at establishing the parameters to allow digital exchanges to inter-work with one another and with digital transmission systems. This work will fall within the overall strategy established by C.C.I.T.T. Study Group XVIII (digital networks), an instance of the importance of common membership of the C.E.P.T. and C.C.I.T.T. Technical Groups.

Important aspects of this work will be defining a common channel signalling system to interconnect s.p.c. digital exchanges using a 64 kbit/s data-signalling link and on establishing the criteria for the design and interconnection of synchronous networks.

It can be seen that much of the work of CS, as of C.C.I.T.T. Study Groups XI and XVIII, involves new concepts and the introduction of a wide range of new systems and equipment. For many years to come, agreement can only be sought at the lowest level, corresponding to the traditional C.C.I.T.T. Recommendations for inter-working. However, there will be opportunities as digitalization proceeds of achieving functional interchangeability for new equipments, avoiding national options and of reaching agreement on maintenance and operational aspects which will reach the second level of harmonization.

(*e*) *Data Communications Working Group* (*CD*)

CD is continuing its past programme which closely parallels that of C.C.I.T.T. Study Group VII (data networks). Substantial progress has been reached in defining the essential elements of a synchronous data communications network, submultiplexing 64 kbit/s digital paths compatible with p.c.m. telephone transmission. There is, as yet, no general commitment to implement this kind of network, either nationally or internationally, and it is not possible to

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foresee when it would be appropriate to take this work beyond the first level of harmonization. The emphasis in data networks, both in C.C.I.T.T. and in C.E.P.T., has shifted towards packet switching networks and considerable progress in establishing concepts and interfaces has been made under the stimulus of national and international commitments. The Euronet project has played a catalytic rôle by directing attention to problems and providing opportunities for solutions to be found for a real project to meet a real timetable.

(*f*) *Transmission Working Group* (*TR*)

TR has a solid foundation of achievement to build on since, in effect, it extends the mandate of an earlier subgroup which has been concerned since 1968 with establishing the functional requirements of the 30 channel p.c.m. multiplex system. This work has led to a C.C.I.T.T. Recommendation G732 and to a C.E.P.T. specification which represents a substantial degree of harmonization, almost in the range of Level 2. There are no plans to consider harmonization of analogue (i.e. frequency division multiplex) transmission systems.

In extending its scope, TR has identified five technical areas for harmonization; these are as follows:

(i) video-telephone;
(ii) mechanical environment and power supply;
(iii) digital cable transmission (terminal and line aspects);
(iv) digital radio relay systems;
(v) physical media (cables, etc.).

Progress on the first two of these areas is unlikely to be very rapid; the service and market requirements for video telephony are not yet established, while mechanical and supply practices represent the highest level of harmonization (Level 3) where manufacturing and operating interests are deeply involved. However, useful work could be done on racking and cabling practices and on environmental aspects such as uniform specifications for apparatus rooms in terms of temperature, humidity and electromagnetic interference.

The digital transmission and the radio relay harmonization programmes parallel the studies of the C.C.I.T.T. (Study Group XVIII particularly) and the C.C.I.R. (Study Group 9); representatives of the Secretariats of these organizations will be invited to participate in the C.E.P.T. studies. These studies will follow the digital hierarchy already established for Europe (C.C.I.T.T. Recommendations G744 and G751 refer) and shown in figure 2. Working Group TR will proceed in the next few years to establish more detailed specifications for the various stages of multiplexing equipment and transmission systems at the various levels. These will cover transmission on various media; initially on coaxial cables and radio links in the 13, 15 and 19 GHz bands and eventually on optical fibres. Table 2 summarizes the types of transmission that are likely to be standardized.

For all these equipments the problems to be resolved are essentially the interfaces (along the lines already established in C.C.I.T.T. Recommendation G703 but with unique recommendation rather than optional alternatives and with additional functions for maintenance) and complete specifications for jitter. Jitter remains a difficult problem; present indications are that jitter may be controlled by providing the requisite amount of storage between digital line sections.

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Other items of equipment to be dealt with include various encoders (for high-quality sound, supergroup and hypergroup assemblies), trans-multiplexers (i.e. means for transforming a multiplex signal representing an assembly of telephone channels from t.d.m. to f.d.m. and vice versa), and means for accessing the individual time slots of a p.c.m. frame (essentially defining a 64 kbit/s interface for data and signalling submultiplexing equipment).

TABLE 2

system	digital rate/(Mbit/s)	telephone channels
symmetrical pair	2.048	30
coaxial cable		
1.2/4.4 mm	139.264	1920
0.7/2.9 mm	8.448	120
0.7/2.9 mm	34.368	480
radio relay		
13 GHz	34.368	480
15 GHz	2 × 8.448†	2 × 120
19 GHz	139.264	1920
	or 2 × 139.264†	2 × 1920

† Two streams (at 8.448 or 139.264 Mbit/s) on a single r.f. carrier.

Work on physical media is for the present likely to be concentrated on the electrical characteristics of complete repeater sections for two or three types of cable, although the longer term importance of optical fibre is recognized and will be considered when the techniques are more firmly established. The small coaxial cable (1.2/4.4 mm) is already well established in large scale production and use for wide band analogue transmission (up to 12 MHz line band width corresponding to 2700 telephone channels). It is being used on an increasing scale in the U.K. for digital transmission at 120 Mbit/s. The existing C.C.I.T.T. recommendations for this cable represent a high degree of harmonization, adequate to meet the needs of the 12 MHz f.d.m. system. New performance requirements, to meet the needs of digital transmission at up to 140 Mbit/s, will be identified and incorporated in an extension to the cable specifications. The harmonization programme will aim to recommend preferred sizes of cable (i.e. the number of coaxial pairs) and lay-up assemblies.

A smaller diameter coaxial cable, so-called microcoaxial (0.7/2.9 mm), already in use in some countries in Europe, may also feature in the harmonization programme, as a bearer for digital signals at 8.448 or 34.368 Mbit/s (120 or 480 telephone channels) together with a symmetrical-pair cable, essentially an improved form of existing audio frequency cables, suitable for digital transmission at 8.448 Mbit/s.

Local cables, i.e. those connecting subscribers to their local exchange, have not hitherto been the subject of detailed international recommendations. However, the I.E.C., prompted by countries which do not manufacture these cables and by agreement with the C.C.I.T.T., has recently decided to standardize a range of local cables. This work will be complemented by a C.E.P.T. harmonization programme.

(*g*) *Participation of industry*

At the inception of C.E.P.T., and for so long as its activities were confined to operations and tariffs, it was appropriate for participation in the activities of C.E.P.T. and the range of

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consultation and dissemination of information to be confined to the Telecommunications Administrations of Europe. As C.E.P.T's studies extended into the field of technical specifications for systems and equipment and its study programmes paralleled those carried out by the C.C.I.T.T. Study Groups it became necessary to consult outside interests, particularly the European telecommunications manufacturers. These discussions were carried on at the national level, that is to say between each telecommunications authority and its indigenous manufacturers or representatives of importers. So long as the technical programmes pursued in C.E.P.T. remained within the ambit of corresponding studies in C.C.I.T.T. this degree of consultation was adequate although it did contrast, sometimes harshly, with the direct participation of representatives of telecommunications manufacturers in the work of the C.C.I.T.T. either as experts attached to national delegations or in an advisory capacity as representatives of industrial organizations. The undertaking by C.E.P.T. of a harmonization programme, however, prompted a reappraisal of the rôle of industry in the technical studies carried out by the C.E.P.T. Working Groups. It became evident as the higher levels of harmonization were defined, leading to functional harmonization, elimination of national options and eventually possibly to the adoption of standard practices in mechanical construction, component and quality assurance standards, that the introduction of manufacturing expertise was essential in order that satisfactory standards would be laid down and since industrial property rights would inevitably be involved. Two possible levels at which there could be interaction between C.E.P.T. and the manufacturing industries in Europe were identified; a policy level on the range, depth and speed at which harmonization might be pursued in telecommunications, and at the detail level on specific equipment or system topics. The Coordinating Committee for Harmonization, CCH, has been empowered to involve manufacturers at whatever level seems appropriate; at the policy level, the Chairman of CCH could, in principle, discuss harmonization with representatives of the European telecommunications industry but this is not possible in practice because no such representative body exists. From time to time, therefore, the Chairman of CCH has addressed an open letter to the European manufacturers setting out the broad aims and progress of the harmonization programme and copies of this letter have been sent by the telecommunications authorities in each member country to the appropriate industry representatives. In the United Kingdom it has been convenient to focus harmonization discussions on representative bodies, the Telecommunication Engineering and Manufacturing Association (T.E.M.A.) and the Telephone Cable Manufacturing Association, and they have nominated technical experts who will, in the first instance, cooperate with the Post Office in detailed technical studies on the harmonization programme. CCH has authorized Working Groups concerned with harmonization to include industry experts on appropriate occasions in their technical studies and this arrangement is beginning to operate. As the harmonization programme proceeds, greater involvement of industrial experts may be expected.

It is too early to forecast the pace of the harmonization programme and its effects. Given that the resources available for technical studies are limited there will be a continuing conflict between two alternative courses of action. Either a wide range of topics can be covered at the lowest level or a small range can be taken to the higher levels of harmonization. There will also be conflicts on timing, whether harmonization is to be pursued as a short term or long term objective. The present decade is seeing a great upsurge in new technologies giving opportunities for an increased range of services and for overall economies if a sound basis of agreement on essential principles is secured.

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Clearly, such opportunities must not be sacrificed for the hypothetical benefits of equipment standardization. Such standardization, as an end in itself, may be the enemy of innovation.

7. Future rôle of the consultative committees and regional bodies

The growth of regional bodies such as C.E.P.T., pursuing technical studies paralleling those of the C.C.I.T.T. and to a less extent those of the C.C.I.R. inevitably raises the question of the future rôles of these bodies. Suggestions have been made that the long time-scale in which the C.C.I.T.T. and C.C.I.R. operates, in progression from the initial framing of a question, its adoption by the next Plenary Assembly and the years of study until a recommendation is finally adopted by a succeeding Plenary Assembly, are unacceptably long in the light of the pace of modern technical advance. Following this line of thought it is said that the search for world-wide agreement takes too long and should give way to regional agreements, such as the European agreements for the R2 signalling system and the 30 channel p.c.m. system. These views ignore the essential world-wide nature of telecommunications as regards both operations and manufacture. At present there are two regional groups so far as technical standards are concerned. In North America, Bell System pioneering developments lead to early, sometimes premature, standards being set and adopted by non-Bell companies so as to simplify interconnection and sharing of markets. C.C.I.T.T. and C.C.I.R. standards tend to reflect the need of many administrations for an external standard. Because technical progress is somewhat slower outside the United States, the opportunity arises to profit by the pioneer's experience. The growing complexity and the increasing interaction between national networks and services demands that differences between the principal networks be minimized (Wallenstein 1974). It is perhaps paradoxical that the move from analogue to digital systems is increasing the rigidity of networks so that present incompatibilities will lead to great difficulties in future inter-working.

The dilemma of the rôles of regional bodies and the C.C.Is can perhaps be resolved by seeking to ensure that studies are complementary and not competitive. C.C.I.T.T's rôle must give priority to establishing the conditions for inter-working and to defining the basic services and network parameters. Regional bodies may build on this base to establish higher levels of agreement. Individual administrations faced with limited resources should aim to restrict the range of topics dealt with but should pursue them thoroughly.

It is interesting to speculate on the possible consequences of a change in the positions of the Bell companies *vis-à-vis* Western Electric and the Bell Telephone Laboratories in the U.S.A. Removal of the links that bind these three parties together in a uniquely strong partnership could increase the influence of C.C.I.T.T. and C.C.I.R. recommendations in North America; redirection of Western Electric's production resources in search of markets outside the Bell companies could restore the influence of Bell standards and practices on world telecommunications which was a feature of the early decades of this century.

8. Conclusions

So far, the industrial countries of North America and Europe have led the way in international standards for telecommunications; this is consistent with the concentration of 80 % of the world's telephones in these two areas. In the past decade the total number of telephones in

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the world has doubled, representing an average growth rate of about 6 % per annum. However, the growth rate of some countries in South America and Asia in percentage terms is nearly double this. The long term growth potential for the world is therefore very large and countries in other continents, given continued economic growth, may come to represent the dominant market for basic telecommunications equipment. Their growth, combined with the development of communications via satellite, may lead to network patterns of great complexity. At the same time the industrial countries will be introducing new technologies and new services. Thus the work of the I.T.U. and the Consultative Committees will continue to expand at the two levels representing the interests of the developed and the developing countries. Communication satellites will be a common factor uniting the different interests. It is important, therefore, that the study programmes of the Consultative Committees should concentrate on essential matters and maintain a proper balance between system technology and operational or network aspects of global telecommunications. Similarly, regional organizations such as C.E.P.T. must keep a proper perspective so that regional standardization is not pursued to the detriment of world-wide inter-working. Achieving harmony between North American and European networks should continue to be a cardinal aim but this may require short term commercial interests to be subordinated to long term considerations.

It must, moreover, be accepted that the present rapid introduction of new technologies and new services and the expansion of automatic networks in many developing countries is building up maintenance liabilities for the future. Operating authorities will have to respond to this challenge and create administrative machinery able to deal efficiently with multilateral negotiations. Possibly, experience with operation through Intelsat and other consortia may suggest an approach. It seems inevitable that a heavy burden will fall on Study Group IV of the C.C.I.T.T. while securing adequate trained manpower and maintenance equipment at new centres in the world network may be a task requiring particular attention by the I.T.U.

Permission of the Senior Director, Development of the United Kingdom Post Office to make use of official information and contributions of former colleagues are acknowledged.

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