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SPECIAL ISSUE ON TELECOMMUNICATIONS IN DEVELOPING COUNTRIES

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(Committees continued on Cover III)

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Guest Editorial

Telecommunications in Developing Countries

THIS IS the first special issue of the IEEE TRANSACTIONS ON COMMUNICATIONS to be devoted exclusively to the extensive subject of telecommunications in developing countries. It comes at the time of the centennial celebration of the invention of the telephone by Alexander Graham Bell and the bicentennial celebration of the United States of America—a country responsible for an age of technological innovations in telecommunications. As a result of these innovations in telecommunications, it is possible to connect almost instantly any two subscribers from over 90 percent of the telephones in the world, whether they be in a rich, industrialized, developed country or a poor, agricultnrally oriented developing country. The massive telecommunication network is a way of life for many national and international organizations trying to solve global problems and conflicts. A special issue on this subject is also very timely from the viewpoint of recent and active international debates between the developed and developing world aimed at analyzing the problems and demands of developing societies, as well as the recent concern of engineers for the overall social implications of technology such as telecommunications. It is this environment of international understanding and social concern that motivates us to analyze the problems of telecommunications in developing countries from the viewpoint of humanitarian needs rather than profit-oriented market potentials.

The present world population of over 4 billion can be categorized in three groups: 1) the developed First World of about 25 industrialized countries with 750 million citizens, 2) the Second World with 1.3 billion people in socialist countries, and 3) the developing Third World consisting of about 100 countries and over 2 billion citizens. Essentially, within the free world, telecommunication technology has been a part of a long history of interaction and cooperation between developed and developing nations. As a result of this cooperation, the developing world, with about 22 million telephones, enjoys the benefits of the invention of Alexander Graham Bell.

Presently, telecommunication in the Third World countries is primarily used for government and business purposes. It has evolved in a disorderly manner without integrated planning. Lack of technology and capital has resulted in obsolete equipment, a long waiting period, unreliable service, and poor voice quality. Needless to say various national and international agencies have been and are attempting to solve some of these problems. Recently, it has been emphasized that telecommunications has a role to play in the overall development of a country. However, with limited resources in terms of time, technology, and capital, these countries cannot afford to stress telecommunications development when food, housing, and education are greater priorities. Then the question is, how can we effectively utilize scarce resources to provide better telecommunication facilities aimed at achieving humane conditions for over 2 billion people? This issue attempts to answer some of these questions.

The overall objective of this special issue is to promote an awareness of the state of telecommunications in developing countries and to suggest alternatives based on indigenous models and basic needs. Specifically, with this special issue we hope to: 1) provide some educational background material for engineers and planners, 2) raise some important issues of general interest on overall planning, services, and technology, and 3) foster dialogue betweeu several national and international agencies and interdisciplinary groups such as economists, sociologists, politicians, rural planners, etc.

In planning the format for this special issue, there were two choices. One was to publish strictly technical and product-oriented material based on new innovations, experiments, and equipment from various developing countries. The other was to emphasize global concern and include articles of general topics such as present status, planning, policy, and problems. It was felt that the first approach would most probably result in articles of old imported equipment and would not contribute to the understanding of the basic telecommunication needs of developing societies. As a result, the second approach with a global outlook was selected. As published in our Call for Papers, we emphasized papers on specific topics such as the state of telecommunications in a developing country, associated problem areas, improvement strategies, indigenous models, planning guidelines, and policy implications.

The overall response to our Call for Papers was excellent. We received over 30 papers for review, of which only 17 could be accommodated due to space limitations. The papers included in this special issue fall into three broad categories: 1) the existing state of telecommunications, 2) planning and policy, and 3) specific application areas.

The first category includes a group of five papers on the existing state of telecommunications in developing countries. The first paper in this group is a review paper that defines the notion of developing countries, provides various telephone statistics (number of telephones, population density, demand, etc.), and outlines typical organizational structures and technology. The two sides of telecommunications in developing countries are mentioned: the administrative side that emphasizes growth and production, and the user side that represents a long waiting period, heavy investment, poor voice quality, and inadequate maintenance. The remaining four papers discuss telecommunications in a specific developing country. G. Bayraktar and H. Abut discuss the "Present State and Future of Telecommunications in Turkey." Their projections suggest that capital investments on telecommunication services must be at least doubled in order that the standards in Turkey compare with those of the world averages. K. Soewandi and P. Soedarmadi outline telecommunications for Indonesia where the geographic configuration of over 3000 inhabited islands requires special microwave and domestic satellite facilities for local transmission. "A Communications Explosion in Oman" is described by R. L. Scrafford. Due to the small size of the country and available petro dollars, Oman has a unique opportunity to build a completely new telecommunications system. Scrafford outlines the present domestic and international telecommunications network in Oman and discusses future development programs. " Iran's Present Telecommunication System and Its Expected Development" are discussed by G. R. A. Tourzan. He outlines network philosophy, subscriber plant, manufacturing companies, and special services in Iran.

The second category includes a broad range of papers and focuses on planning and policy issues. The first paper in this group, by G. D. Wallenstein, describes the role of the International Telecommunications Union in satisfying the needs of developing countries. The recent participation of these countries in various plenary sessions is reviewed in detail. Wallenstein concludes that the ITU exhibits two faces, one directed toward the highly developed country, and another toward the developing country in need of help. The L. A. Gimpelson paper emphasizes a need for proper planning in developing countries. Essentially, he discusses the planning task, forecasting, services, technology planning, and flexibility. The role of "Telecommunications as a Factor in the Economic Development of a Country" is investigated by D. J. Marsh. He correlates the growth of the telecommunications network with the economic growth of a country in an attempt to optimally allocate capital resources. This paper presents the results of the use of a macroanalytic technique in correlating various factors for several selected countries in Latin America. The results are then discussed in the context of basic telephone demand parameters and the current dynamic technological and economic environment. B. B. Wellenius focuses on "Some Recurrent Problems of Telecommunications in Developing Countries." The main focus of this paper is concentrated on four classes of problems related to method; namely, demand forecasting, economic evaluation, pricing, and technological dependence. This paper concludes that dealing with these and related problems of method needs an essentially interdisciplinary approach. "Some Implications of Telecommunication Policies in Developing Countries" are outlined by B. Prasada. He points to the urban–rural dichotomy in many developing countries and proposes two distinct networks, urban and rural. Establishment of a national rural telecommunication agency is suggested to implement the concept of rural networks. H. Chasia provides discussion on the main constraints on the choice of technology and emphasizes those that are related to the socioeconomic enviornment in the rural areas. A discussion of technology transfer is also included. Tlus paper is based on the role of teleconmunications in East African development. S. Pitroda, in his paper "Telecommunication Development–The Third Way," suggests that the solutions io the problems of the developing countries have to come from within. None of the developing countries has the resources and know-how to solve the massive communication problem and, as a result, an autonomous technology center responsive to all developing countries for design and development is suggested. A new concept of community telephones which deemphasizes telephone density is introduced and several organizational and administrative changes are also suggested.

The third group of papers deal with specific application areas. In particular, five papers related to satellite and microwave communications are included. I. Goldstein's paper on "INTELSAT and the Developing World" includes discussion on the Third World relationship and the contribution of INTELSAT. It outlines the INTELSAT system, developing world requirements, allotment capacity, terms and conditions, and operational benefits related to satellite programs. The role of developing countries in the political and financial structure of INTELSAT is also explored. The "Pan-African Telecommunication Network: A Case for Telecommunications in the Development of Africa" is presented by P. O. Okundi. Some of the special problems and constraints associated with African continental telecommunications are reviewed. A description of the Pan-African network is given, together with traffic predictions. The L. T. Brekka and B. B. Lusignan paper discusses the role of educational television and the associated communication network to educate people in Iran with resources for rapid economic development. Indigenous "Microwave System Development in India" is highlighted by D. K. Sachdev. An interesting history of a large technological undertaking in a developing country like India is included with discussion on early struggles, design feedbacks, and the results of a recent development effort. A note on the lessons derived from this experience is also included. Finally, a paper on the "Low-Power-Consumption Microwave Radio Relay System" by T. Kawahashi *et al.* is included to emphasize the need for a new product design approach geared toward the requirements of developing areas. For example, it uses the solar cell, a highly desirable power source in some developing countries, for the normal system power supply.

Needless to say, the global aspects of telecommnnications in developing conntries include a large number of topics that enlarge the scope of our special issue and make it difficult to accommodate all areas of interest. We hope in this limited space we have at least made an attempt to educate and sensitize engineers for further involvement and generate awareness among interdisciplinary groups such as planners and administrators for action in appropriate organizations.

The Guest Editor would like to express his thanks to Amos

Joel, Past President of our Communications Society, for his encouragement and C. A. Pleasance and Dr. D. L. Schilling for their continued interest in the special issue. Special thanks are due to Ms. Sue Tallerino and Ms. Nancy Cox for administrative assistance and Lloyd Eckel for editing some material related to this issue. The effort involved in preparing this special issue will have been more than justified if the papers published stimulate discussions and generate additional original ideas to efficiently utilize limited telecommunication resources for improving human conditions in developing countries.

SATYAN G. PITRODA
Guest Editor

Satyan G. Pitroda (Sattu) (M'67) was born in Titilagarh, India, on November 16, 1942. He received the B. S. and M. S. degrees in physics from Maharaja Sayajirao University of Baroda, Baroda, India in 1962 and 1964, respectively, and the M.S. degree in electrical engineering from the Illinois Institute of Technology, Chicago, in 1966 where he continued additional postgraduate work for the doctoral program.

His experience includes electron paramagnetic resonance, nuclear multichannel analyzers, design of high-speed A/D converters, video bandwidth compression techniques, modulation concepts, PCM T1 carrier systems, synchronous and asynchronous data transmission, digital tone detection, tone generator and conference technqiues, PCM digital networks, network synchronization, line concentrators, remote switching units, private automatic branch exchanges, digital central office switching, tandem switching systems, system software, hardware/software tradeoffs, and microprocessor-based concepts. He is a consultant in telecommunications and microprocessor-oriented consumer and medical products. He is presently associated with Wescom, Inc., Chicago, IL, and is directing the company's development efforts in telecommunication switching. Earlier, he was with General Telephone and Electronics where he made a significant original contributiou to their telecommunication switching products. He holds over 25 worldwide patents and has presented and published numerous papers. He is also the author of a forthcoming book on PCM telecommunication technology.

Mr. Pitroda is a member of the American Association for the Advancement of Science.

To,
My life long friend
Dr. Bhupen C. Trivedi
with compliments.
[signature]
8/16/76.

State of Telecommunications in Developing Countries—An Overview

SATYAN G. PITRODA, MEMBER, IEEE

Abstract—This paper examines the state of telecommunications in developing countries with special emphasis on telecommunication technology and telephone statistics sueh as number of telephones, telephone density and demand.

First, the notion of a developing world is formulated in terms of social and economic conditions, and its existing telecommunication needs are reviewed. Then the state of telecommunication is portrayed in terms of various international telephone statistics and is compared with those of the industrialized world. Typieal government-controlled telecommunication organizations responsible for providing telephone services, associated manpower, and training needs are then diseussed. The technology is reviewed from the viewpoint of local capabilities, ancillary industries, and foreign know-how as well as the pricing policy for telecommunication services, based on highly unsatisfied demand. At the eud, two aspects of telecommunication iu developing countries are explored: 1) the administrative aspect that emphasizes growth and production, and 2) the users' aspect that represents a long waiting period, heavy iuvestment, poor voice quality, and inadequate maintenance.

INTRODUCTION

COMMUNICATION, which arises as a response to personal relationships, collective behavior, education, trade, etc., plays a significant role in the history of human development. The science of modern communication was born during the last century, when the message speed of 30 mi/h, over any long distance, which tied inextricably to land transportation, and which had remained constant for over 5000 years, was suddenly changed to match the speed of light. Over the last 125 years, communication science has changed from a laboratory curiosity to a highly complex electronic industry. It has changed from an ordinary local telegraph service to direct international dialing for instant worldwide connection for voice, video, aud data through satellites. It is this development of modern communication with its highly technical and vastly advanced electronic methods that has aided in creating the technological civilization responsible for providing the present high living standards in industrialized countries.

Since the industrialized nations were responsible for originating and developing the present communication technology, considerable attention has already been given to new equipment, services, and associated social implications [1]. However, the impact of modern communication ou developing countries has not been fully explored. Communication technology in these countries has developed under strong influences from industrialized nations through import of equipment and technology. In order to understand the role of communication in these countries, an overview of the present status is desirable.

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The object of this paper is to review the state of telecommunications in developing countries. First, the notion of a developing world is outlined from the viewpoint of social and economic conditions. Then the telecommunication facilities are reviewed with special emphasis on telephone statistics (such as number of telephones, telephone density, and demand) and telecommunication technology (such as local, ancillary, and foreign). This paper also discusses a typical government-controlled organization and associated manpower and training needs. It is observed that there are two aspects of telecommunication in developing countries: the administrative aspect that emphasizes growth and production, and the users' aspect that experiences heavy initial investment, poor voice quality, and inadequate maintenance.

DEVELOPING WORLD

The present world community of 4 billion people in about 125 countries forms a complex society that can be analyzed through several world indicators expressing the state of affairs in a particular society. The leading socioeconomic indicators are based on the gross national product (GNP) and reflect the absolute per-capita terms. Based on these leading indicators, the present world community, as shown in Fig. 1, can be divided into three groups, as follows.

1) The developing first world of about 25 advanced industrialized countries such as the west European nations, United States, Canada, Japan, Australia, New Zealand, and South Africa. Countries like Argentina, Greece, and Spain are also included in this group. These countries, having about 750 million people, support a "free market" oriented economy, consume most of the world's resources, produce most of its marketed goods and services, and enjoy history's highest standard of living.

2) The second world, with 1.3 billion people in socialist countries, includes the east European nations, U.S.S.R., China, Laos, North Korea, Vietnam, Cambodia, etc.

3)The developing third world with over 2 billion people in about a hundred countries is characterized by multiple problems, such as those related to burgeoning population, agriculture, housing, transportation, education, and many other important amenities of life. It includes the countries of Asia (excluding Japan), Africa (excluding South Africa), Latin America (excluding Argentina), Oceania (excluding Australia, New Zealand, and U.S. Hawaii), and Turkey and Yugoslavia from Enrope.

No standard definition of a developing nation is applicable nor is any precise set of criteria established to draw a line of division between underdeveloped, developing, and developed nations. Generally speaking, the developing nations are synon-

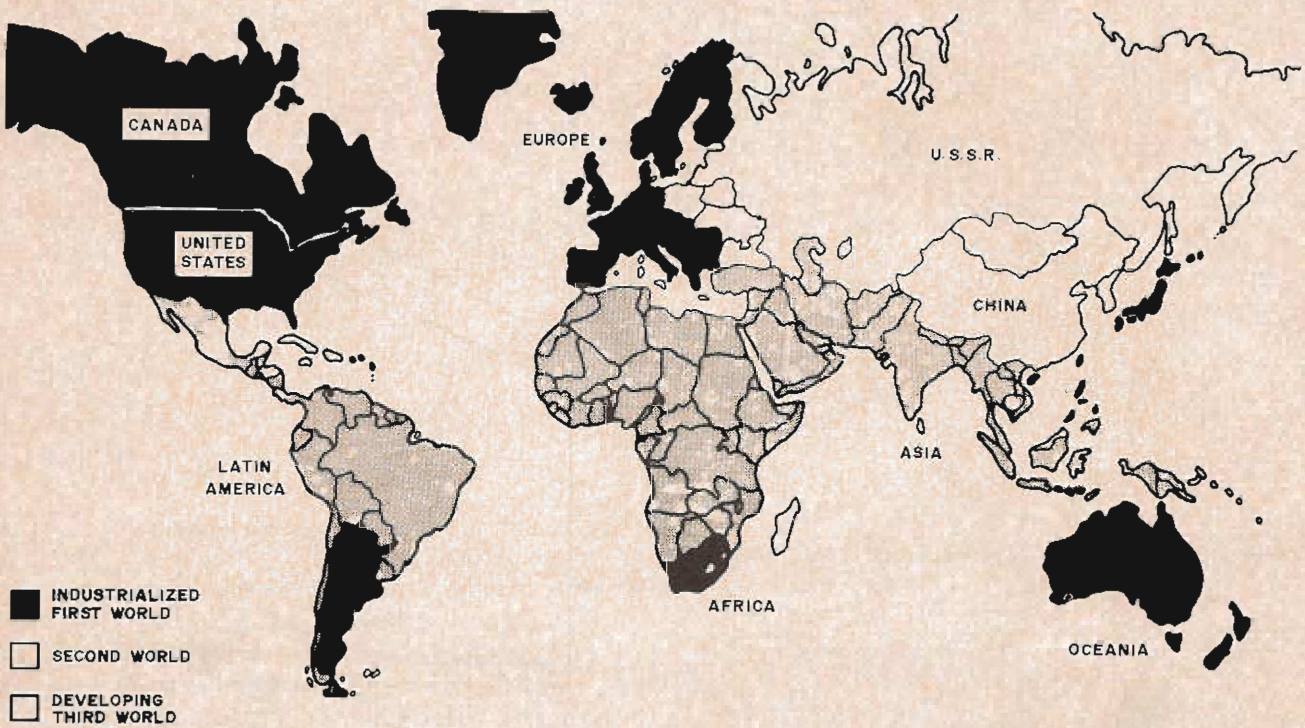

Fig. 1. Three worlds.

ymous with the third world, where things are in flux, institutions are not yet formalized, and economic and technical maturity is yet to be achieved.

The present developing world with half of the world's total inhabitants, is divided into two groups; one with economic stability resulting from oil export or key natural resources and the other with some raw material resources but no capital to invest. Both groups require organization, administration, technology, skilled manpower, and the time to generate self-sustaining growth.

(It should be noted that the technocratic idea of expressing the state of affairs of a society in terms of social indicators is being questioned by a number of scholars. It cannot be overemphasized that GNP does not directly reflect the state of personal happiness, well being, self-realization, and several other factors that affect the conditions of health of a human society.)

TELECOMMUNICATION NEEDS

The present telecommunication needs of developing nations arise from a drive to ensure social and political order and to increase industrial production to bridge the development gap. As a result the existing telecommunication networks serve mainly government and business organizations. They provide an infrastructure for the operation of an industrialized, diversified economy that depends on exchange of vital information among several parties. They are also needed for efficient distribution of goods, such as food and clothing, and essential services, such as medical and legal needs.

(The present networks do not reflect the real needs of developing countries; neither do the priorities set by their governments. Communication researchers and policy planners have recently been studying basic telecommunication needs from the viewpoint of social development. Their findings indicated that the state of the present networks result from disorderly evolution without the integral planning required to serve the rural population, which constitutes over 70 percent of the inhabitants in these countries.)

TELEPHONE STATISTICS

Telephone statistics are vital in providing an overview of the state of telecommunication in a particular country. The *Yearbook of Common Carrier Telecommunication Statistics* published by the International Telecommunication Union [2] and *The World's Telephones* published by American Telephone and Telegraph Company [3] contain detailed telephone statistics from all over the world. These international statistics are analyzed to compare the conditions in developing countries with those of the industrialized world.

On Jan. 1, 1974, there were 336 297 000 telephones in the world, serving about 4 billion people. This amounts to 8.6 telephones per hundred people--a telephone density of 8.6. The distribution of these 336 million telephones in six continents is shown in Fig. 2. The United States leads the world with 138 million telephones. Nearly 80 percent of the world's telephones are in North America and Europe. The remaining 20 percent are distributed in four continents: Asia, 15 percent; Latin America, 3.3 percent; Oceania, 2 percent; and Africa, 1.2 percent.

Fig. 3 shows the distribution of telephones among three worlds by continents. The developed first world has 86 percent of the total telephones. The socialist second world has 7 percent, and the developing third world has the remaining 7 percent. Based on this, the developing countries in Asia have

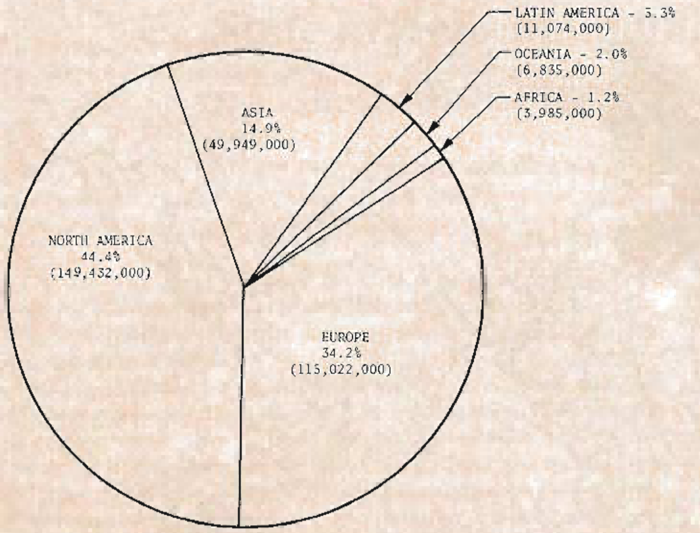

Fig. 2. World telephones by continents (as of Jan. 1974).

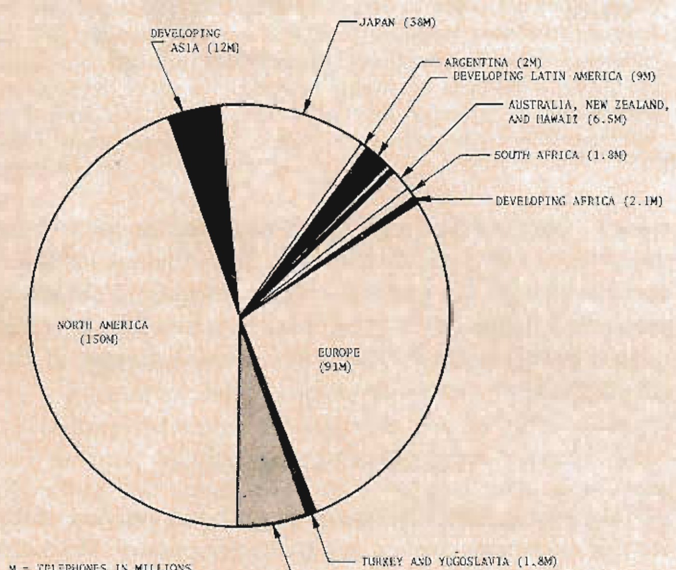

Fig. 3. Distribution of telephones among three worlds by continents (as of Jan. 1974).

3.5 percent, in Latin America 2.6 percent, and Africa 0.5 percent of the world's telephones. As shown in this figure, the majority of the phones in Asia are located in industrialized Japan (38 million). A small number of phones (1.8 million) from the European continent are in developing Turkey and Yugoslavia. About 23 million telephones in Europe are estimated to be in the socialist countries of the second world.

The growth of telephones in the three worlds over the last ten years (1964-1974) is shown in Fig. 4. It is interesting to note that in the last decade the world's telephones have doubled. This multiplication is worldwide, both in developed and developing countries. However, the growth in the socialist second world has been slow compared to the developing nations. The telephone growth in the six continents over the last 50 years (1925-1975) is shown in Fig. 5. From this figure, it is apparent that the take-off period in North America

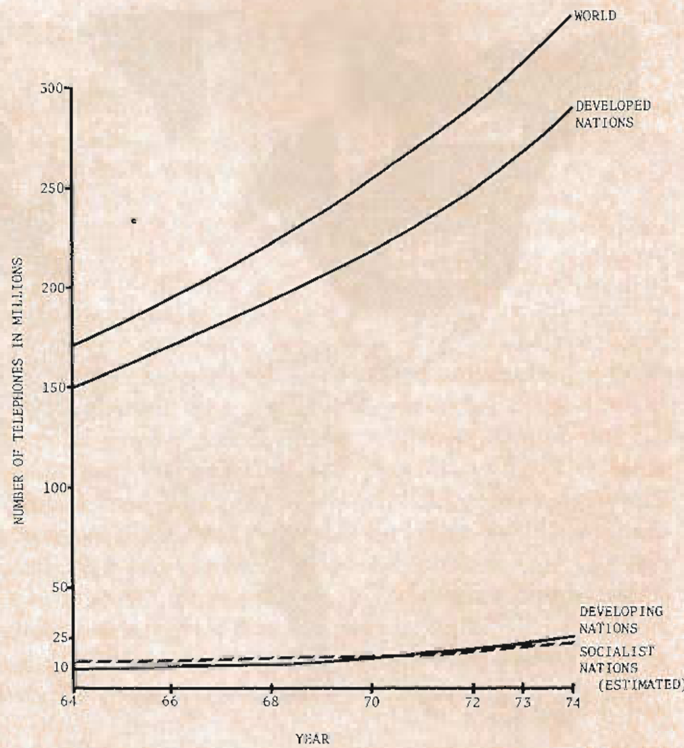

Fig. 4. Telephone growth in three worlds (1964-1974).

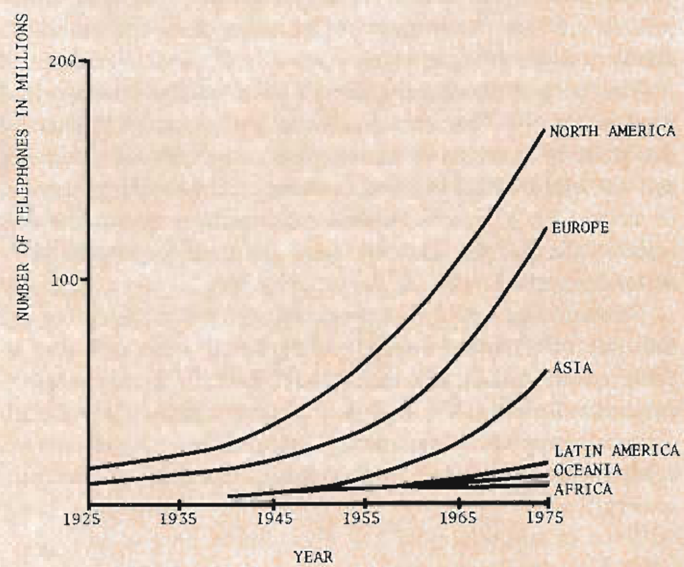

Fig. 5. Telephone growth in six continents (1925-1975).

and Europe began in the 1930's. The Asian growth started in the early 1950's with significant expansion in Japan. The growth in Latin America and Africa began only during the early 1960's. The average growth rate of the six continents over this 50-year period is shown in Fig. 6. On an average, the worldwide growth has been close to 7 percent per annum. The depression of the 1930's is seen by an annual growth of less than 1 percent in North America during the 1930's. It is interesting to note that the North American continent is reaching its saturation point and the growth rate has slowed since 1955. At the same time, the annual growth rate in all developing continents has been increasing. The average annual

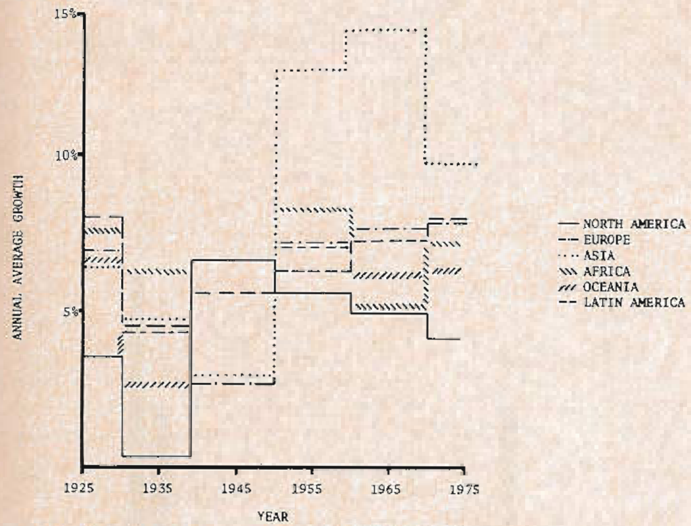

Fig. 6. Annual average growth rate by continents (1925–1975).

growth rate in Asia has been significant with about 10 to 15 percent. Based on this, it appears that the telephone growth in the developing world will continue to be greater than the world averages for years to come.

Fig. 7 shows the telephone growth of the developing world by continents during the last 10 years (1964-1974). As indicated here, the number of telephones in developing Asia has increased from 5 million in 1964 to 12 million in 1974. Similarly, in developing Latin America, the number of telephones has increased from 3.8 million to 9 million. Compared to this, the growth in Africa and Oceania has not been significant. The telephones in Turkey and Yugoslavia, developing Europe, have also increased from 0.7 million to 1.8 million during the same period.

The absolute number of telephones do not necessarily represent the true state of telecommunication development in a particular country. As a result, it is desirable to compare telephone density (the number of telephones per 100 people) from various countries. Fig. 8 represents telephone density of select countries in six different continents; with the average telephone density of each continent shown in gray areas.

The North American continent has the highest telephone density of 64 with the United States having about 66 phones per 100 people. It should be noted that the developing countries of Asia, Africa, and Latin America have very low telephone density. The telephone density of Oceania is high (32), due to the contribution from Australia, New Zealand, and Hawaii. The average telephone density of the world is also shown in Fig. 8. Based on the available population figures and the number of telephones during 1974, it is estimated that the telephone density of the developed first world is about 40. The socialist second world has a telephone density of 1.76 and the developing third world has 1.15 phones for every 100 people.

The relationship between telephone density and gross national product (GNP) has been studied to determine the role of telecommunication as a factor in the economic development of a country. This relationship for selected countries is shown in Fig. 9. From these data, it is clear that the countries with high GNP have high telephone density. The developing countries of the third world with low GNP per capita have low telephone density.

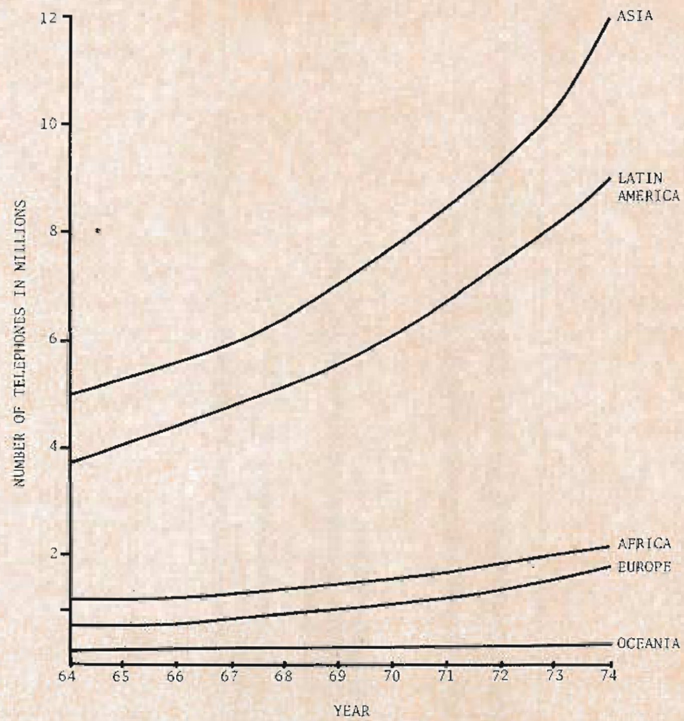

Fig. 7. Telephone growth of developing world by continents (1964–1974).

Several of the telephone statistics, such as the number of local and international calls, telex terminals, local and international telex calls, automatic versus manual telephones, and telegraph centers, are available for individual countries in *The Yearbook of Common Carrier Telecommunication Statistics.* The information regarding the anuual gross investment for telecommunication in each country is also available from the same source.

From all these statistics it is clear that a very small portion of the world's telephones are in developing countries. These countries have a low telephone density and a high growth rate. In particular, the annual growth rate in Asia is considerably higher than the world averages. The growth in a selected group of Asian countries is shown in Table I. The demand in these countries is so high that in spite of the major expansion projects, it cannot be satisfied in the near future. For example, in a country like India, it takes anywhere from three to five years to get a telephone connection (Table II). It should be noted that this list does not include those who are aware of the long waiting period and do not wish to register.

ORGANIZATION

The organizations responsible for telephone services can be classified into three groups: 1) private with governmental supervision (in U.S., Mexico, etc.); 2) semi-governmental (in United Kingdom, Australia, and Sweden); or 3) government-controlled (in countries of Latin American, Africa, and Asia).

In most developing countries, government-controlled organization is responsible for providing telephone services. The

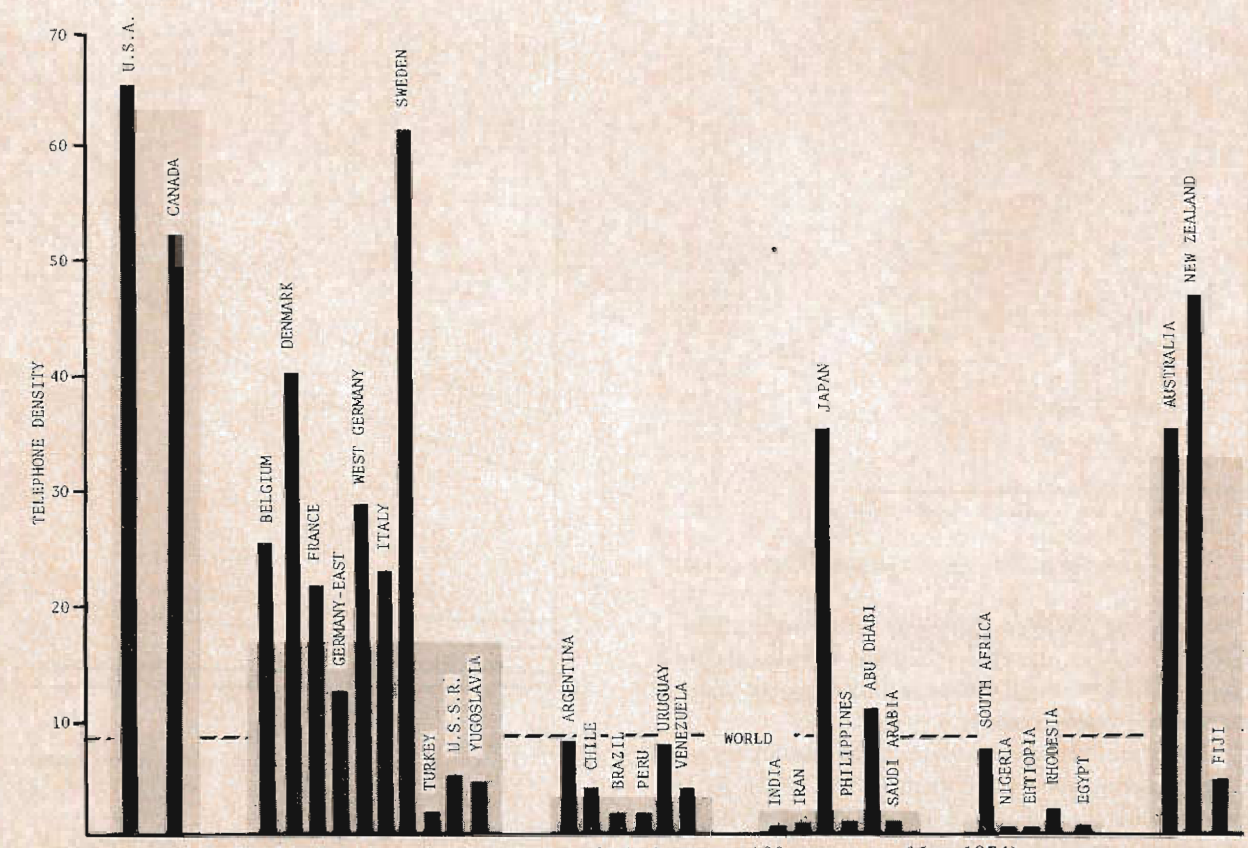

Fig. 8. Telephone density (number of telephones per 100 persons as of Jan. 1974).

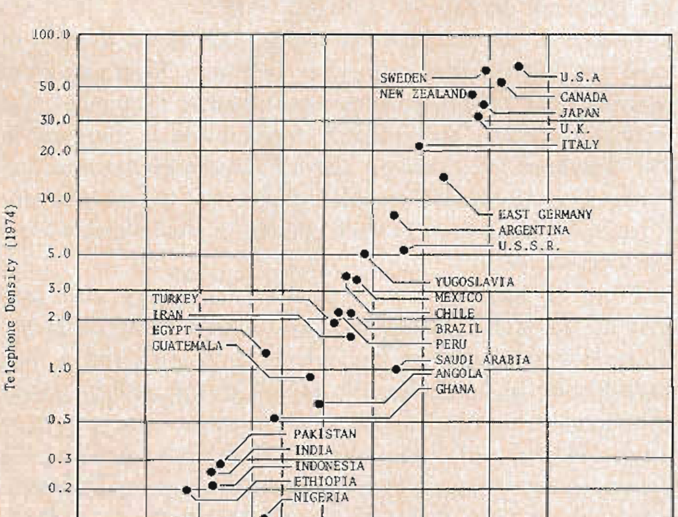

Fig. 9. Telephone density and GNP per capita.

ministry of communication of the central government is charged with the overall responsibilities to administer the post, telegraph, and telephone department (PT & T) for national and international telephone services. In most cases, the department is responsible for providing equipments (through outright purchase, foreign collaborations, local production, etc.) and services (through operating companies). The department also maintains planning and research staff for future expansion programs.

The finances for the development come from the central government and are subjected to other priorities. In most cases, developing countries are finding great difficulties in securing the capital required for expansion. The problem of capital inadequacy was clearly pointed out in a subcommittee report submitted to the Transport and Communications Committee of the Economic and Social Commission for Asia and the Pacific. The recommendation was to invest 0.5 percent of the gross development product of a country. This amounts to about 15 to 20 percent of the resources deployed for economic development. This type of capital cannot be generated by developing countries and as a result, they look forward to "autofinancing" and "aid loans" from world bank organizations.

One of the most important aspects of a massive telecommunication organization is its manpower requirement in a variety of highly specialized fields of expertise. In fact, due to widely dispersed operation resulting from low telephone density, significantly more people are required in developing countries. (In reality, the situation is quite different. For example, in a developing country like India it is estimated that one in every 10 000 people is engaged in telecommunication services. However, in a developed nation like Sweden, with a population of less than 10 million people, about 50 000 are employed in telephone industries—one in every 200 people.)

For proper manpower needs, recruiting, planning, and professional training are essential. The staff requirement for telephone administration varies from normal production-oriented people to highly specialized engineers and administrators. The local universities provide graduates needed for high-level technical and managerial jobs, but they cannot be used in the telecommunication field without the major training programs. They lack proper experimental background,

TABLE I
GROWTH IN A SELECTED GROUP OF ASIAN COUNTRIES

Countries	No. of Telephones		% Increase	Number of Years Taken to Double the Assets
	1964	1974		
Behrain	5,016	17,657	252	5
Bruei	1,200	7,788	549	3
Hong Kong	178,285	913,411	412	4
India	684,284	1,590,000	132	8
Indonesia	149,090	268,963	80	13
Iran	160,000	552,500	245	6
Korea	170,765	1,014,016	494	4
Laos	1,031	5,506	434	5
Nepal	1,500	9,162	510	4
Pakistan	107,334	195,325	81	11
Philippines	146,663	410,290	180	7
Thailand	55,219	264,548	379	4

TABLE II
TELEPHONE WAITING LIST IN INDIA (1964-1973)

YEAR	POPULATION m	TEL. ON WAITING LIST
1964	475	256,918
1965	487	295,557
1966	477	349,226
1967	511	389,600
1968	524	430,159
1969	537	427,630
1970	544	414,378
1971	547	-
1972	562	341,109
1973	580	405,100

due to the lack of modern laboratory facilities, and industrial contacts and exposure.

The impact of proper training aspect has been recognized in industrialized countries for over 50 years. In the developing world, systematic training in an organized fashion for professional advancement and improvement began only recently through cooperation of the International Telecommunication Union. To meet the growing needs several countries have set up training courses that include programs for apprenticeship, junior technicians, senior technicians, engineering specialists, field engineers, training instructors, administrative assistants, and management.

TECHNOLOGY

The telecommunication technology requires knowledge in interdisciplinary sciences due to complex system structure, national and international compatibility, high reliability standards, and long operating life. In order to review the state of telecommunication technology in developing countries it is important to discuss its history and present equipments and manufacturing approaches from the viewpoint of local capabilities, ancillary industries, and foreign know-how.

Traditionally, the telecommunication technology has been imported in all developing countries. The lack of know-how in this complex field, long learning period, scarcity of basic components, and lack of technocratic leadership have forced administrations in developing countries to invite multinational corporations from the industrialized countries to set up facilities. For example, prior to the mid 1960's, many of the national and international services in Latin America were provided by foreign-owned and/or controlled multinational corporations. The present situation in virtually all developing nations is that the franchises to foreign companies have been terminated or are being terminated leaving either the government or the national public corporation responsible for telecommunication services.

As mentioned earlier, historically, the multinational corporations were responsible for providing telecommunication technology to the developing countries through cooperation and ownership. They were responsible for both aspects of the telecommunication business: 1) manufacturing (related to equipments) and 2) services (related to telephone operations and maintenance).

In the developing nations, during the initial manufacturing phase, all the designs were based on imported concepts and used imported components. The local labor force was used mainly to assemble the equipments. The high-level administrators were also imported and the local technical contribution was negligible.

Slowly, the local public corporations started taking over the service responsibilities. In some cases local production was started, utilizing indigenous components. At present, equipments in virtually all developing countries are based on this historical development. These equipments are either imported or locally assembled from imported designs. It is only recently that some of the developing countries have started developing their own telecommunication equipments.

Basically the telecommunication system can be divided into three areas: 1) terminal equipments, 2) carrier, and 3) switching.

The terminal equipments include telephones, telex, teleprinters, etc. The present telephone instruments in developing countries are mainly rotary dial type and are locally manufactured in several countries. The push button phones without multifrequency dialing are available only for decor. The existing networks in developing countries are rarely equipped to handle multifrequency dialing. The carrier facility includes open wire, buried cable, and multichannel frequency-modulated systems. Recently there has been a great demand for microwave facilities. In some countries even domestic satellite is being used for national and international communications. It should be noted that the majority of the multichannel services are analog. The PCM digital services are in experimental and field trial stages in some countries. The switching systems which form a part of the telecommunication network are mainly electromechanical–Strowger and/or crossbar type. These systems have electromechanical control and are designed to handle low traffic. Several administrations are planning to install computer-controlled electronic switching systems in the near future. In brief, the technology being used in these three areas is traditional and borrowed from industrialized nations.

The technology related to system planning and electronic devices is virtually unavailable in developing countries. Most of the system planning is based on models in the indnstrialized world. The International Telecommunication Union and other similar organizations have been assisting developing countries in setting standards and guidelines needed for overall system planning. The device technology virtually depends on the semiconductor component industries of the developed world.

It is interesting to note that in the industrialized world presently there are significant changes occuring in the telecommunication technology due to the impact of digital components. It is believed that medium-scale integration (MSI) and large-scale integration (LSI) are going to revolutionize telephone business by providing reliable digital integrated transmission and switching equipments at significant cost savings. At this time when microprocessors are burgeoning, the developing countries are just getting a grasp of the computer-controlled switching systems and associated advantages. Based on impressions, it may be safe to say that the understanding of telecommunication technology in developing countries lags by about a decade.

Now that the local administrations have the responsibility for services in most of the developing countries they are faced with selecting a manufactnring approach. Basically, there are two options: 1) followed by oil-producing countries with foreign exchange to spare; and 2) followed by others that emphasize import substitute by indigenious components.

Recently, several oil-producing countries have been announcing massive plans to improve their telecommunication networks. Their plans are based on hiring the best available talent to engineer facilities and invite multinational corporations to either set up local capabilities in collaboration or furnish necessary hardware. This approach begins with total foreign know-how and hopes to provide local capabilities through cooperation. It is based on a "complete package" concept and is independent of the present local conditions. It briugs in equipments designed for conditions elsewhere and may pose problems in training for self-reliance.

The second approach results from scarcity of foreign exchange. Due to the lack of available foreign exchange the administration is forced to substitute imported elements. This indigenous development approach reqnires a certain type of industrial infrastructure and manpower within the country. In fact, in this case the role of ancillary industries becomes extremely important.

In most of the developing countries the electronic industry at this stage is developed to a point where basic components like resistors, capacitors, transistors, etc., are manufactured locally. However, these components are geared to consumer industries, such as the radio, and are not suitable for high-grade communication equipments. The communication equipments need components with long operating life and precise tolerances.

In brief, for local production of modern telecommunication equipments a mature ancillary industry is imperative. India has been successful in developing indigenous telecommunication systems in recent years [4]. The required infrastructure of industries, educational institutions, and major laboratories is available in India to support modern development programs.

The uncertainty of making the right choice of technology and appropriate strategies from the expanding variety of options which are increasingly available for developing countries is one of the major planning problems. The question regarding what is appropriate and what is not appropriate has been raised several times. There are two schools of thought on this. One believes in using old electromechanical-type borrowed technology which is "proved" and requires continuous maintenance to keep more people employed. The other believes that the developing countries must stop following and start leading by leapfrogging through the use of new technology.

PRICING POLICY

In a majority of the developing countries with government-owned and/or operated telephone networks, the investment capital is derived through government borrowings and internal resources of the revenue of the department. The investment, however, is subject to budgetary control within the framework of government programs. The government board not only approves the total budget but also very tightly specifies the amount of foreign exchange allowed for the expansion programs. The pricing policy for telephone services in most of the developing countries is based on this type of controlled budget where expansion is limited to available foreign exchange. Needless to say that, this is not the case with the oil-producing Middle Eastern countries.

Since the demand is considerably higher than the supply in these countries, the normal strategy of coping with the unsatisfied demand is to attempt to control and dampen it through high initial investment. As a result very few people can afford private telephones in developing countries.

The level of rate structures for telephone services varies widely. In most developing countries, it is desirable to follow measured rate service with a low fixed monthly charge compared to flat rate service with unlimited loeal calls. The measured rate is preferred beeause its rates are sensitive to every outgoing call and as a result, tend to reduce unnecessary local calls. It helps to reduce the load on the network which is normally congested with heavy traffic generated from low telephone density.

OBSERVATIONS

Based on the overview of the state of telecommunications and personal experience with services and facilities, it appears that there are two aspects of telecommunication in developing countries: 1) administrative aspect; and 2) users' aspect.

The administrative aspect relates to the viewpoint of a typical communication administrator (working with the ministry of communication) who is concerned with expansion and growth in a developing country. His assessment of telecommunication conditions would probably result in the following observations.

1) Enough share of the available national economic resources is diverted to telecommunication development.

2) The number of telephones has increased.

3) Telephone density has also increased.

4) More equipments are locally manufactured.

5) Import content in the locally manufactured equipment has decreased.

6) Export of telephone equipment and service to neighboring countries has increased.

7) More jobs are created in the telephone industry.

8) Foreign exchange requirements have been minimized.

9) Production facilities have been improved, etc.

In brief, from the administrator's viewpoint, everything is fine and he has the statistical data available to prove his case.

From the users' viewpoint, he is faced with multiple problems that can be categorized in four groups: 1) availability; 2) reliability; 3) poor administration; and 4) others.

Availability: In developing countries, it is almost impossible to get a phone installed within a reasonable time period. It requires heavy initial investment (in some cases, on the order of several hundred U.S. dollars), which is beyond the reach of average middle class people. As a result, only the rich and the elite can afford telecommunication services. When the initial heavy investment is available, the long waiting period is inevitable. In some countries, the waiting period is on the order of 5 to 10 years. The number of public phones is very small. In urban areas where public phones are available, they hardly work. As a result, the average citizen cannot afford the initial investment required to have a private telephone and has no access to a reliable public phone.

Reliability: Reliability problems appear as soon as the telephone is installed. It begins with a long waiting period for dial tone followed by a repeated effort to establish a connection. Many times it takes several attempts for a successful network connection. Once the connection is established through repeated dialing, it is normal to get a multiparty connection where at least three conversations are progressing. The quality of voice is very poor and any long-distance call invariably requires a shouting match. The telephone instrument is normally old and bulky and requires frequent maintenance. These maintenance complaints are not always sincerely recorded. The response to telephone repair service is far from adequate.

Poor administration: The experience of a subscriber with the telephone administration begins through operator assistance. The operators generally lack telephone manners and the education needed to help the subscribers. They are poorly equipped, with hardly any of the sophisticated tools which would help them to provide proper assistance; nor do they get proper updated local and long-distance directories. Complaints at the administrative office rarely result in immediate action for service improvement.

The normal complaint is that of over-billing. In most cases, due to old equipments and inadequate record keeping, frequent billing errors occur. The subscriber is billed for services never used. In these cases, the subscriber is forced to pay for administrative errors and asked to request a refund that requires additional administrative entanglement. Several cases in developing countries are known where home phones were billed for a large sum of telephone calls from business customers. In order to continue priviledged and prestigious telephone services, the subscriber had no choice but to pay the bills first and then ask for the refund.

Others: In developing countries, the user is faced with several other problems related to telephone services beside availability and reliability. Normally, new services are limited and infrequent. The "black market" activities related to obtaining the initial telephone line and the selling of services on manually operated long-distance networks for personal financial gains also pose several problems.

In brief, there is a great contradiction between these two viewpoints. However, it should be noted that the ultimate objective of the telephone administration is to provide reliable access to a national telephone network for a large population at a minimum cost: This does not mean that the administration should respond quickly to unsatisfied demand and plan on providing private telephones in any household. The overall telecommunication objectives have to be consistent with the available national resources and should be designed to satisfy the ultimate user irrespective of his or her social status. The telecommunication services in a developing country should be required for social and economic development and must include the needs of a large rural population. This represents a great challenge to administrators, planners, and engineers for the next decade to come.

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Satyan G. Pitroda (M'67), for a photograph and biography, see page 675 of this issue.

Present State and Future of Telecommunications in Turkey

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Abstract—The public telecommunication network of Turkey is briefly discussed in this paper. The existing telephone, telegraph, data, and other related services are summarized, and future trends in some of these services are indicated. These trends suggest that capital investments on the telecommunication services must be at least doubled in order that the standards in the country compete with those of the world averages. Finally, some of the research in communications is cited.

I. INTRODUCTION

TURKEY is a developing country of 776 000 km^2 with a population of 40 million, a gross national product per capita of approximately 6000 TL (equivalent of U.S. $400) and 598 954 main telephone subscribers according to 1974 statistics [1].

The General Directorate of P.T.T. is the authority for the setting up and the operation of all public telecommunication facilities in the country. In addition to telephone and telegraph services, the necessary channels for the Turkish TV and some military networks are supplied by the P.T.T. administration. A brief overview of the present status and of the trends in the development of telecommunications in the country will be presented in the following sections.

The development rate of Turkey has been about 7–10 percent yearly during the first thirteen years of the planned development period of 1963–1995.[1] The programmed development plan forecasts that the country will reach the standards of the social welfare and industrialization of the Western European countries by the end of 1995 [2]. The importance of this last date lies in the fact that Turkey will become a full-fledged member of the European Economic Community (EEC) in 1995.[2] Hence, the country should accomplish her development systematically and rapidly so that the transition to membership in the EEC can be an easy one.

The existing telecommunication facilities should be increased greatly, in parallel with improvements in social and economic welfare. New services employing modern digital systems must be extensively established to catch up with the world standards. To achieve this, it has been decided in the Third Five-Year-Plan to: 1) increase the investments in telecommunications services; 2) have a national electronics industry satisfying the market demand; and 3) fulfill the demands for communication systems and devices through local sources.

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[1] First Five-Year Plan period: 1963–1967; Second Five-Year Plan period: 1968–1972; Third Five-Year Plan period: 1973–1977; planned development period: 1963–1995.

[2] Turkey has been accepted as a candidate to membership in the EEC with a 25-year transition period according to an agreement signed in 1970 in Ankara.

II. TODAY'S TELEPHONE NETWORK

A well-established measure of the telephone services in a country is the telephone density q defined by the number of main subscribers per 100 inhabitants. Table I shows the rate of growth of the telephone services over the years 1955–1974 in Turkey [1], [3]. If we glance at the figures in the table, we see that the telephone density is increasing at a rate of about 10 percent. Since there is a commonly accepted regression between the telephone density q and the gross national product (GNP) per capita [4], [5], it would be worthwhile to compare these values with those of the world standards. Fig. 1 shows the relationships between the telephone density and GNP per capita using 1971 price indices for Turkey. In the same figure, a similar relation using the averages of 70 developed and developing member-countries of ITU for the years 1964–1968 is also plotted.

The telephone density in Turkey with a U.S. $400 GNP in the early seventies is around 1.5 percent, whereas an average value for the developed and developing countries in 1964–1968 was above 2.1 percent. Thus, there is a gap of 0.6 percent between the national network at present and the world average of 1964–1968. This rather pronounced gap must be closed by allocating more funds to the telephone industry investments.

The network is by no means satisfying the demand. The number of people waiting for the extension of telephone services is increasing drastically every year. This trend is shown in Table II. However, the delays and shortcomings in extending services to potential customers are increasing at a smaller rate every year, which is a somewhat promising indication for future trends.

III. TELEGRAPH AND DATA SERVICES

The telegraph network is complete country-wide, interconnecting the towns and cities in Turkey. But the telex network is continually taking the place of the classical telegraph network throughout the country. There were 3950 telex terminals in 1974. During the same year, there were about 1200 potential subscribers. The ratio of potential customers to the existing ones is more than 0.3.

Data transmission facilities are not provided by the P.T.T. administration at present. The rate of growth of this service is not clear as there are no previous statistics available for reference. Nevertheless, data communication systems research is underway at a few institutions.

A very limited number of facsimile transmission networks exists among the big cities. But the customers, mainly the

TABLE I
TELEPHONE DENSITY IN TURKEY OVER THE YEARS 1955–1974

Years	Number of Main Telephone Subscribers	Yearly Increase in Telephone Subscribers %	Telephone Density %	Yearly Increase in Telephone Density %
1955	116 465	------	0.484	------
56	133 328	14.49	0.539	11.36
57	154 316	15.74	0.607	12.62
58	167 230	8.37	0.639	5.27
59	172 765	3.31	0.643	0.63
1960	180 030	4.21	0.649	0.93
61	191 287	6.25	0.689	6.16
62	195 367	2.13	0.664	3.77
63	199 451	2.09	0.657	1.07
64	210 183	5.38	0.674	2.59
1965	243 361	15.79	0.775	14.99
66	262 547	7.88	0.816	5.29
67	275 380	4.89	0.831	1.84
68	288 057	4.60	0.858	3.25
69	330 904	14.87	0.961	12.00
1970	376 987	13.93	1.059	10.20
71	426 377	13.10	1.177	11.14
72	473 462	11.04	1.275	8.33
73	531 367	12.25	1.385	8.62
74	598 954	12.70	1.500	8.30

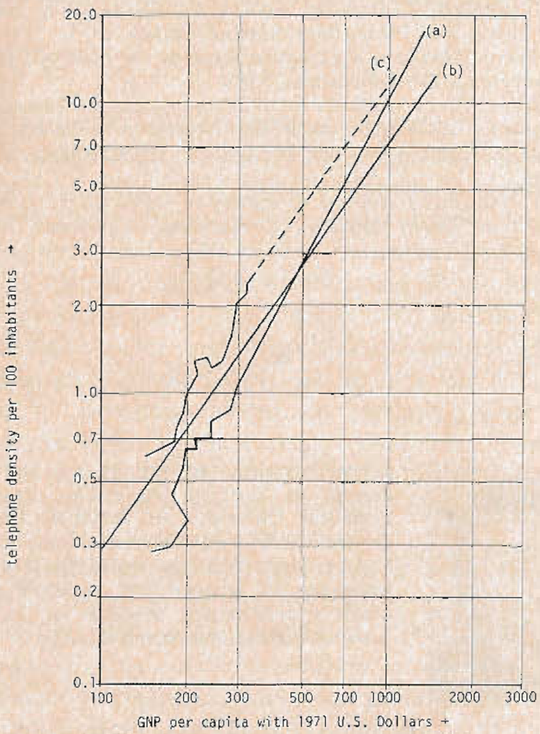

Fig. 1. Relationship of telephone density to GNP per capita. (a) Curve for the existing telephone services. (b) Curve for the average of member countries of ITU. (c) Projections of the expected potential telephone density.

press, are responsible for the total terminal equipment, leaving only the necessary channel allocation to the P.T.T. people.

The Turkish Radio and Television Organization (TRT) is using the P.T.T. radio-links, with all the necessary connections being provided by the P.T.T. servicemen.

P.T.T. renders also special network services among the various military installations of the national, NATO, and CENTO organizations.

IV. FUTURE TRENDS IN TELECOMMUNICATION SERVICES

A measure for the future trends of expectations from the telephone services is the relationship between the potential telephone density and the GNP per capita. The potential telephone density is defined by the sum of the total telephone subscribers and the customers waiting for telephone installations per 100 people for a given year. Table III shows this trend over the period 1972–1995. The expected growth in the

TABLE II
UNSATISFIED DEMANDS IN TELEPHONE SERVICES OVER THE PERIOD OF 1968–1974

Years	Number of Customers Waiting for Telephone Installations	Yearly Rate of Increase %	Ratio of Satisfied Customers and Unsatisfied Demands
1968	215 552	------	0.75
1969	264 919	22.90	0.80
1970	329 954	24.55	0.88
1971	359 354	8.91	0.84
1972	395 971	10.00	0.84
1973	403 000	2.10	0.74
1974	408 000	1.24	0.65

TABLE III
EXPECTED DEMAND FOR TELEPHONE SERVICES FOR THE PERIOD OF 1972–1995

Years	Potential Population in millions	Potential GNP per Capita using 1971 prices U.S. $	Potential Telephone Demand	Potential Telephone Density (%)
1972	37.6	324	870 000	2.31
1977	42.3	414	1 379 000	3.26
1982	47.9	552	2 297 000	5.00
1987	54.7	737	4 004 000	7.36
1992	60.8	1050	7 198 000	11.95
1995	65.2	1293	10 432 000	16.00

TABLE IV
EXPECTED GROWTH IN TELEX TERMINALS

Years	Number of Existing Telephone Subscribers	Number of Existing Telex Terminals	Yearly Increase in the No. of Telex Terminals %
1972	473 462	3950	------
1977	960 000	6720	14.0
1982	1 864 000	13050	14.0
1987	3 549 000	24840	13.7
1992	6 725 000	47080	13.6
1995	9 877 000	69140	13.7

telex network is summarized in Table IV. It is clear that the number of requested telex terminals is being doubled every five years.

In order to achieve the figures given in Tables III and IV, the investments in the telecommunications industry must be, on the average, 3.4 percent of the total investments using the 1971 prices for the period of 1977–1995. However, the programmed investment allocation for the year of 1977 is only 0.357 of the GNP, or equivalent to 1.6 percent of the total capital investments. The last figure is less than half of the required amount. Therefore, a higher percentage must be allocated to this industry in the Five-Year Plans starting in 1978.

The second major and decisive factor in the future of telecommunication-services trends would be the solution of the technical personnel problem. In almost all of the developing countries, this factor is inseparable from the previous one, the increase in investment allocations in order to carry on the development plans systematically and rapidly. We feel that the technical personnel problem in Turkey is one which can be dealt with some hope of success. Once the personnel are better paid, this problem will be solved almost completely because nearly all of the technical staff employed in the telecommunication services are graduates of the national technical institutions.

The percentage of students in the electrical engineering department of Turkish universities constitutes almost 2 percent of the total higher education enrollment which is around 200 000 [6]. Since the early sixties the demand for electrical engineering studies is increasing at a much higher rate than the capacity increases in the schools. Therefore, every year a smaller percentage of the demand is being satisfied by means of a selection process through the Turkish Universities Entrance Examinations.

On the other hand, the staffing problem of the institutions is a stagnant one due to the underpayment of the civil servants. This, in return, has caused a considerable brain-drain to the Western European countries, U.S.A., Canada, and even Australia.

It is obvious that Turkey will need a young technical cadre available for designing, enlarging, establishing, maintaining, and managing the future telecommunication services. To fulfill these requirements, the Third Five-Year Plan includes the following suggestions to the government for taking the necessary measures: 1) to increase the number of academic staff; 2) to extend the possibilities and the capacities of the educational institutions; and 3) to end the brain-drain from the country.

V. COMMUNICATIONS RESEARCH IN TURKEY

The institutions where theoretical and experimental research is being carried out in communications are the Electronics Research Unit of the Marmara Research Institute, the P.T.T. Research Laboratories, and the electrical engineering departments of the universities.

At the Marmara Research Institute of the Turkish Scientific and Technical Research Council, 1) theoretical and experimental work on modems employing FSK and DPSK systems for the audio channels is being carried out, 2) a prototype of 32-channel PCM system for short-haul trunks is being developed, and 3) studies on digital filters are underway.

At the P.T.T. Research Laboratories, 1) development work of high channel capacity FDM equipment and high speed telegraph systems for the national network is being carried on and 2) a 24-channel VHF and a 60-channel UHF radio systems are under study.

In the universities, theoretical and experimental investigations are being carried out. Some of these projects are partially financed by the Turkish Scientific and Technical Research Council. But these funds are incomparably meager with respect to those in the developed countries, and hence the number of technical papers appearing in the international journals on the subject is very limited. The other shortcoming in research is connected with the staffing problem of the Universities. Since the departments are understaffed, the existing personnel have very limited time to divert from their daily course work to research. The authors believe that distributing more funds to fundamental research in communications holds much more promise for the future than the existing state of affairs.

VI. CONCLUSIONS

The telecommunication services in Turkey are far below the world standards. The expected rate of growth is tremendously high but even that would not be sufficient to meet the potential demands. On the other hand, research in communications is significant. In conclusion, Turkey must allocate more funds for telecommunication investments and support more research projects in order to cope with world standards.

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Telecommunications in Indonesia

K. SOEWANDI AND P. SOEDARMADI

Abstract—The telecommunicatious in Indonesia is reviewed with emphasis on transmission and switching networks. It is recognized that due to the geographical configuration of Indonesia, problems are created in the field of telecommunication that require special transmission consideration. The existing Perumtel's Transmission Network and Domestic Satellite Project Palapa 1 are discussed. The future expansion programs in transmission and switching are also briefly reviewed.

INTRODUCTION

AN island country, Indonesia is a collection of more than 13 000 islands (3000 of them inhabited) spread out between the continents of Asia and Australia. It covers an area of about 3 500 000 square miles, the seas included. Its population numbers about 130 million, the greater part of which lives on the five main islands. More than 60 percent of the total population lives on the island of Java. Jakarta, the capital city with 5 million inhabitants, is situated on this island.

Being a developing nation, Indonesia is facing problems similar to those encountered by developing countries in general. In extending its economy, telecommunication services are regarded as the arteries of the nation to facilitate the flow of goods for export and import, business activities, as well as providing communications between islands.

Due to the geographical configuration of Indonesia, problems are created in the field of telecommunication that require special transmission consideration. This paper presents an overview of the state of telecommunications in Indonesia. It discusses the existing transmission and switching facilities and emphasizes the future expansion projects.

TELECOMMUNICATIONS

In Indonesia, public telecommunication is provided by Perumtel—a Telecommunication Public Corporation, subject to the Directorate General of the Posts and Telecommunications of the Ministry of Communication. It provides services in the areas of telephone, telegraph, and telex, as well as leased channel services for both domestic and overseas communication.

Based on 1973 statistics, the population of Indonesia grew from 105 to 130 million during the last decade (1964 to 1973), while the total number of telephones increased from 169 000 to 269 000 during this same period. These figures reflect an increase in telephone density from 0.16 to 0.21 telephones per 100 people. The outgoing telephone traffic showed a considerable increase from 8.8 million inland calls during 1964 to 256 million during 1973. Similarly, the outgoing international traffic increased from 10 000 calls during 1964 to 288 000 calls during 1973. At present, the revenue generated from the total telecommunication services is in the order of 19 000 million rupiah.

In the case of telex services, local telex calls increased from 461 000 during 1964 to 9.9 million during 1973, while international telex calls increased from 200 to 278 000 during the same period. Compared to telex services, the telegram traffic remained fairly constant. During the same 10-year period, the national telegram traffic increased from 2.9 million to 3.4 million and international telegram traffic increased from 444 000 to 550 000.

TRANSMISSION

One of the toughest problems to be solved in the Indonesian telecommunication field was its transmission system. Before the Java-Bali and Trans Sumatra Microwave Systems were completed, the open-wire telephone carrier system was used in long-distance communications on Java, as well as on several other islands having sufficient traffic.

In providing telecommunication services between Jakarta and the towns outside the island of Java, as well as between other islands, high frequency (HF) systems were used for long distances while very high frequency (VHF) link systems were used for shorter distances. Moreover, communication to the interior regions were carried by open-wire lines without carriers and they formed single connections using local battery telephone sets. As a rule, buried cables are used only for local network in the towns.

A survey on microwave transmission systems in Indonesia was undertaken and completed during 1961. Based on this survey, the first phase microwave project between Jakarta and Bandung was accomplished in six years with great difficulties. The second and the third phases of the project (for services between Bandung–Surabaya and Surabaya–Denpassar) were executed simultaneously and needed a five-year time frame. On March 1973, the Java-Bali Microwave Network operation was inaugurated. This system consisted of 31 terminal and repeater stations stretched throughout the island of Java, connecting several cities beginning from Jakarta and ending at Denpassar, the capital of the isle of Bali; a distance of about 1350 km. The relay station towers were constructed with heights ranging from 10–80 m. Following this, on August 8, 1975, the Trans Sumatra Microwave Network was put into service, connecting Jakarta to Medan at the northern part of Sumatra, linked by 54 terminal and repeater stations, covering a distance of 2066 km.

The East Indonesia Microwave Network, which is planned

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to be completed in 1976, starts from Bali to the east and goes northward as far as Ujungpandang on the isle of Sulawesi. This network will join the Java–Bali Microwave Network in Denpassar.

Due to the long distance over the sea between Java and Kalimantan, the use of a troposcatter system between Surabaya and Banjarmasin was necessary. This was completed during 1975.

In September 1969, the first Indonesian earth station at Jatiluhur, about 100 km east of Jakarta, went into service. The Cassegrain antenna of this station faces out toward the INTELSAT Satellite located over the Indian Ocean. Through satellite communication, Indonesia ensures the provision of reliable international telecommunication links, although some overseas communication links to certain countries are still carried out by HF systems.

In spite of the above mentioned Perumtel's Telecommunication Network, as shown in Fig. 1, the administration is unable to meet the existing demand satisfactorily.

SWITCHING

The switching facilities in Indonesia permit the interconnection of the local telephone network, as well as long-distance circuits. Several methods of long-distance switching are in operation, for example, ring down, operators dialing, and subscribers long-distance dialing (SLDD) according to local networks and transmission facilities. With the completion of the Java-Bali and Trans Sumatra Microwave Networks, 12 cities can be interconnected automatically based on the SLDD principle.

In June 1975, there were only 39 automatic telephone exchanges with a total capacity of 143 000 line units and 507 manual exchanges with a total capacity of 97 117 line units. At this time, there are 15 telex exchanges with a capacity of 1810 line units. From what is pointed out above, it is clear that the capacity of the existing telex as well as telephone exchanges are far below the public demands.

EXPANSION PROJECTS

Transmission

Due to the fact that the facilities offered by Perumtel still cannot satisfactorily fulfill the exploding demand, the Directorate General of Posts/and Telecommunications has decided to expand the Indonesian Telecommunication Network during its second five-year development program. In order to attain all the objectives, Perumtel is carrying out the following major projects.

Domestic Satellite Communication System

Due to Indonesia's geography, it is impossible to provide good service in a short time to remote places and the interior regions by establishing only conventional transmission systems. The study concerning satellite systems showed that natioual telecommunication service (such as television, telephony, telex, leased channels, and data transmission) can be provided using domestic satellites, resulting in minimum cost and faster construction times.

The Indonesion Domestic Satellite concept provides the following advantages:

1) capability to completely cover the whole Indonesian area;

2) development can be carried out simultaneously;

3) higher capacity than terrestrial systems;

4) flexibility to meet any unexpected telecommunication need immediately; and

5) capability to provide facilities for national television, educational television, meteorological services, etc.

Indonesia will be the fourth country after Canada, the United States, and the Soviet Union to adopt the synchronous satellite for solving its long-distance communication problem. In July 1976, it is planned that the 12-transponder satellite made by Hughes Aircraft Company will be launched by NASA from the Eastern Test Range and be positioned over the Indian Ocean. This satellite (the same type as the Canadian ANIK) operates at 6/4 GHz and is called Palapa 1 (Fig. 2).

(Gajah Mada, 14th century Prime Minister of the Kingdom of Majapahit, who wished to unite all peoples living in Nusantara (Indonesia), vowed not to eat "palapa," a great delicacy at that time, until the country was united. To commemorate his sacrifice, the Indonsian Domestic Satellite was named Palapa.)

To snpport this domestic satellite system, 40 earth stations spread throughout the country are under construction. The Master Control Station is located at Cibinong, about 50 km south of Jakarta.

Switching

During Pelita II, the second five-year development program, the number of telephone line nnits will increase from about 240 000 to approximately 690 000. Nearly half of the total amount of the telephone increase is destined for Jakarta. The telephone network in this capital city with 5 million inhabitants will be expanded with 222 000 line units; an increase from 45 000 to 267 000 line units. Most of this expansion will be accomplished using the new electronic switching system (ESS).

For large cities outside Jakarta, the use of ESS systems are also being planned, while smaller cities are planned to still be equipped with a conventional electromechanical system. In addition, mobile exchanges will be used for places in the interior regions and for other places if they are urgently needed.

As a consequence of the switching system expansion, the local network and the trunk facilities must also be expanded. Expansion of the cable duct systems are now under construction. For certain areas where the demands exploded and subscriber connection must be done urgently, pair savers or subscriber carrier systems will also be used. For junction lines, the possibility of using PCM systems are under study. Finally, the number of telex exchanges will be expanded from 15 to 27 with a capacity increase of 10 000 line units.

Fig. 1. Perumtel's Telecommunication Network.

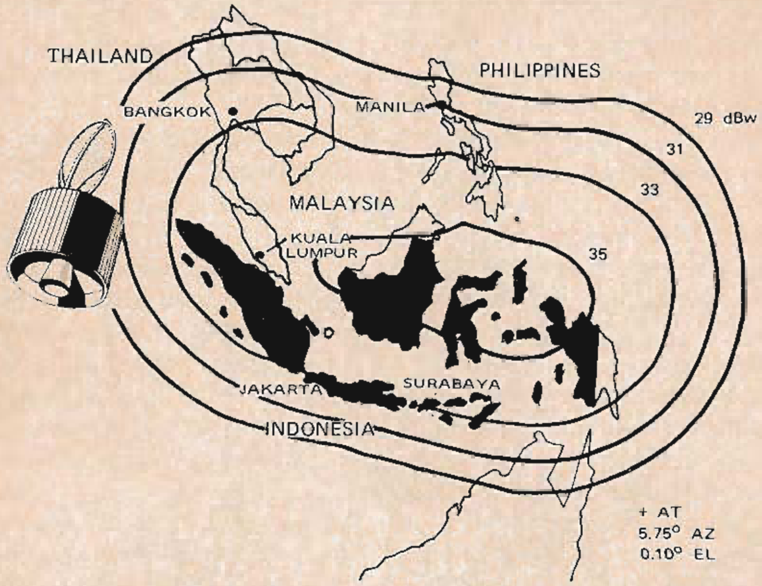

Fig. 2. The area covered by the Palapa 1.

CONCLUSION

After completion of the expansion project, Nusantara Telecommunication Project, it is hoped that Perumtel can adequately meet the urgent needs of the customers, and provide good service to all areas of Indonesia; not only in the field of telegraph and telephones, but also for television, data communication, and other new services.

★

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From 1954 to 1966 he served in the Indonesian Telecommunieation Operational Section. During 1967 to 1974 he worked in the Construction Section of the Indonesian Telecommunication Public Corporations Head Office where he was in charge of the construction of the Java–Bali Microwave System (1969 to 1973) and concerned with the construction of the Trans Sumatra Microwave System. Since 1975 he has been with the Institute for Research and Development of Posts and Telecommunications, Bandung, Indonesia.

★

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In 1955 he joined the PTT Laboratories, Bandung. Presently, he is with the Institute for Research and Development of Posts and Telecommunications, Bandung. He is Project Manager for the Jakarta Switching Project.

A Communications Explosion in Oman

ROBERT L. SCRAFFORD, MEMBER, IEEE

Abstract—Due to the small size of the country and to available petro dollars, Oman has a unique opportunity to build a completely new telecommunieations system. This paper outlines present domestic and international telecommunications networks in Oman and discusses future development programs.

INTRODUCTION

THE Sultanate of Oman is a land of contrasts, of burning light and breathless shade, of sterile thrusting naked rocks flanking a sea of leaping fish. It occupies most of the southeast corner of Arabia, with an inland landscape that bears some resemblance to parts of Arizona in the United States of America. The capital and priucipal city is Muscat. It lies between latitudes of 16° 40′ N and 26° 20′ N, and longitudes of 51° 50′ E and 59° 40′ E. The coastline is 1700 km long. Neighboring countries are Union of Arab Emirates (UAE), Saudi Arabia, and Peoples Republic of Yemen. Land area is 300 000 km^2. Maximum temperatures range up to nearly 40°C in some areas. Total population is estimated at 600 000. The principal source of foreign exchange is petroleum, which has supplanted agriculture.

Since the commencement of the rule of His Majesty Sultan Qaboos bin Said, on July 23, 1970, tremendous progress has been made in modernization of all aspects of life in Oman. Essential services, including telecommunications, have mushroomed to keep up with the rapidly expanding economy. This paper outlines communications development in Oman with special emphasis on domestic and international networks. It also briefly discusses future telecommunications programs in Oman.

DEVELOPMENT OF COMMUNICATIONS

Until 1975, communications in the Muscat area were provided principally by the Muscat and Mutrah Telephone Company, and at the southern extreme of Oman, by the Salalah Telephone Company, serving 2800 and 350 subscribers, respectively. The Muscat area is served with step-by-step exchanges known as Muscat, Mutrah, Minat Qaboos, and Bait-Al-Falaj. Interexchange dialing is by means of a prefix digit. Some important subscribers in outlying areas are served by VHF rather than by physical connections. Interconnection between Muscat and Salalah is by means of three HF radio circuits. The Salalah operation is manual.

Prior to Mar. 6, 1975, Oman was linked to the outside world by HF radio circuits connecting Muscat with Bahrain. These circuits were saturated a large percentage of the time, making it nearly impossible to originate a telephone or telex call from another country to Oman. Outgoing traffic was in a somewhat better postion since priorities could be applied in some cases. Quite naturally, however, the resultant queuing of outgoing calls was responsible for the nonavailability of circuits for incoming calls. It became necessary to arrange for telex calls to be originated from Muscat when an operator at the overseas machine could have tapes prepared for transmission to Oman.

In Jan. 1975, recognizing the urgency of the problem, a decision was made by the Minister of Communications to purchase, as a temporary expeditious solution, a substandard (transportable) satellite communications station. The station was installed and commenced carrying traffic on Mar. 6, 1975. The impact of Oman traffic on the Indian Ocean satellite is dramatically illustrated in Fig. 1. Its effect on the communications user was equally dramatic since normal high-quality telephone and telex circuits became immediately available.

During 1975, the following programs were completed. When fully integrated and working together, these installations will provide a modern telecommunications system which includes: 1) an extensive coaxial system extending north, west, and south from Muscat; 2) a microwave system, equipped for 980 channels, exteuding from Sohar westward to the border with the UAE at Buraimi; 3) a modern national telephone switching system; 4) a new national telephone company (OMANTEL); 5) a new modern headquarters building for OMANTEL; and 6) an INTELSAT standard satellite communications station.

FORMATION OF OMANTEL

Until July 23, 1975, all domestic and international communications in Oman were provided by Cable and Wireless, Ltd., under a franchise from the government. However, the new systems which were due for completion in 1975 had been undertaken solely under the initiative of the Ministry of Communications. In an effort to consolidate the assets of Cable and Wireless on the one side and those being provided by the Ministry on the other side, negotiations were entered into in Jan. 1975, directed toward the formation of a new jointly owned company. This new company, now known as OMANTEL, commenced operation on Aug. 2, 1975. It will be nnder the direction of the Minister of Communications, responsible for all domestic and international communications. Its management is 60 percent governmental and 40 percent Cable and Wireless. It is a unique organization combining the expertise of employees of Cable and Wireless, seconded to OMANTEL, with that of consultants and Omani personnel and trainees. It is anticipated that after a reasonable period of time, OMANTEL will be completely staffed by Omani management and technicians.

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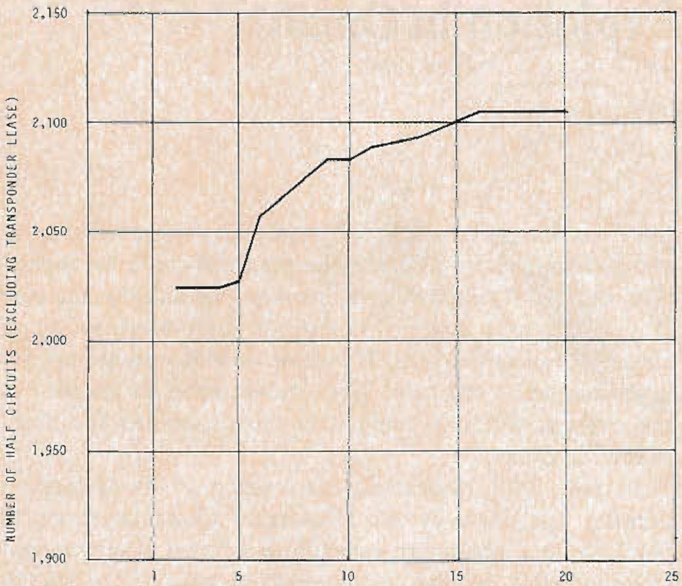

Fig. 1. Daily growth of permanent preassigned INTELSAT traffic (Mar. 1975).

DOMESTIC COMMUNICATIONS

Domestic communications in Oman can be broken down into three categories, as follows: 1) the old Muscat and Mutrah Telephone Company system that had grown with the capital area over a number of years; 2) the Salalah Telephone Company, a manual exchange; and 3) the new coaxial/microwave system provided by L. M. Ericsson.

The new system consists of a backbone four-tube LME coaxial cable carrying 960 channels to Sohar and then one-tube to Khamat Al Malaha carrying 120 channels. Sohar is linked to Buraimi at the border with the UAE by means of a microwave link of 960 channels. The backbone system has several branches and local exchanges as illustrated in Fig. 2.

INTERNATIONAL COMMUNICATIONS

An INTELSAT standard station was inaugurated on Nov. 22, 1975, with a color TV program from Washington, DC, featuring the Sultan speaking to the Omani ambassador.

The site of the INTELSAT standard station, which was constructed by the Consorzio per Systemi di Telecommunicazioni via Satelliti (Italy), is located approximately 12 mi from the new housing area of Ruwi (a suburb of Muscat). It is shielded from the coast and the metropolitan area by a range of hills, with peaks in the vicinity of 600 m. Road access is through a Wadi, which is essentially at the altitude of the metropolitan area. The site is connected to the new OMANTEL communications building in Ruwi by means of a microwave link, employing a passive reflector. A high-tension power line is in the planning stage, and in the interim, diesels will be provided in addition to the no-break system.

The INTELSAT standard station employs an E-Systems 33-m parabolic dish of the latest beam-waveguide design, which allows the feed to be located inside a steel tube in the equipment room, thus permitting convenient access to transmitter and low-noise amplifiers through a short waveguide run. Maximum capacity provides for communications with 13 countries and a total of 60 voice circuits. Equipment is also provided for television transmission and reception.

Initial operation is with two European gateways, the United Kingdom and Italy, thus providing flexibility and security for European and transit traffic. Middle East traffic will be handled directly to countries with sufficient traffic.

DOMESTIC SATELLITE COMMUNICATIONS

At the extreme southern end of Oman is the city of Salalah, a wet and tropical region important for its agriculture, and the residence area for the country's government leaders. During 1976, it is planned to utilize the substandard station, now providing international service, to provide domestic satellite service between Muscat and Salalah.

TRAINING

The training of Omani nationals is an important part of all programs. This is particularly important since individuals with depth of experience are very much in the minority. The staffing of the satellite station, as well as other branches of OMANTEL, is by a mix of foreign and Omani personnel. For the satellite facility, considerable effort was devoted to selecting individuals who had either attended training schools abroad, or who had some suitable on-the-job experience, such as HF or VHF radio. The team was then sent to Europe and the U.S. for training by the equipment suppliers. This training will be supplemented by on-the-job training alongside foreign technicians during actual operations.

FUTURE PROGRAMS

Future programs now in the planning stage include an all-solid-state, computer-controlled international switching system, a domestic satellite communications link to connect Muscat with Salalah 900 km to the south, and a national and international telex system. Long-range programs may possibly include a submarine cable link to Iran and a VHF system to provide service to remote villages, mobile vehicles, and oil drilling platforms. Participation in the Arab satellite system now in the planning stages will be a high-priority item of future planning.

The first step in planning for the future will be the development of a "fundamental plan" by OMANTEL. During 1975, the telephone population of Oman will go from approximately 2500 to 15 000. The impact of this growth on international traffic can only be roughly estimated.

Until development of a fundamental plan, it has been necessary to make some planning estimates in terms of available data. This international traffic planning in terms of international both-way circuits for the first five years is illustrated in Table I. This is certainly a very conservative estimate, based on present requirements plus traditional growth patterns. However, the impact of the extensive growth in telephone population could have a great effect on the growth of international traffic. The potential for this growth is unknown at

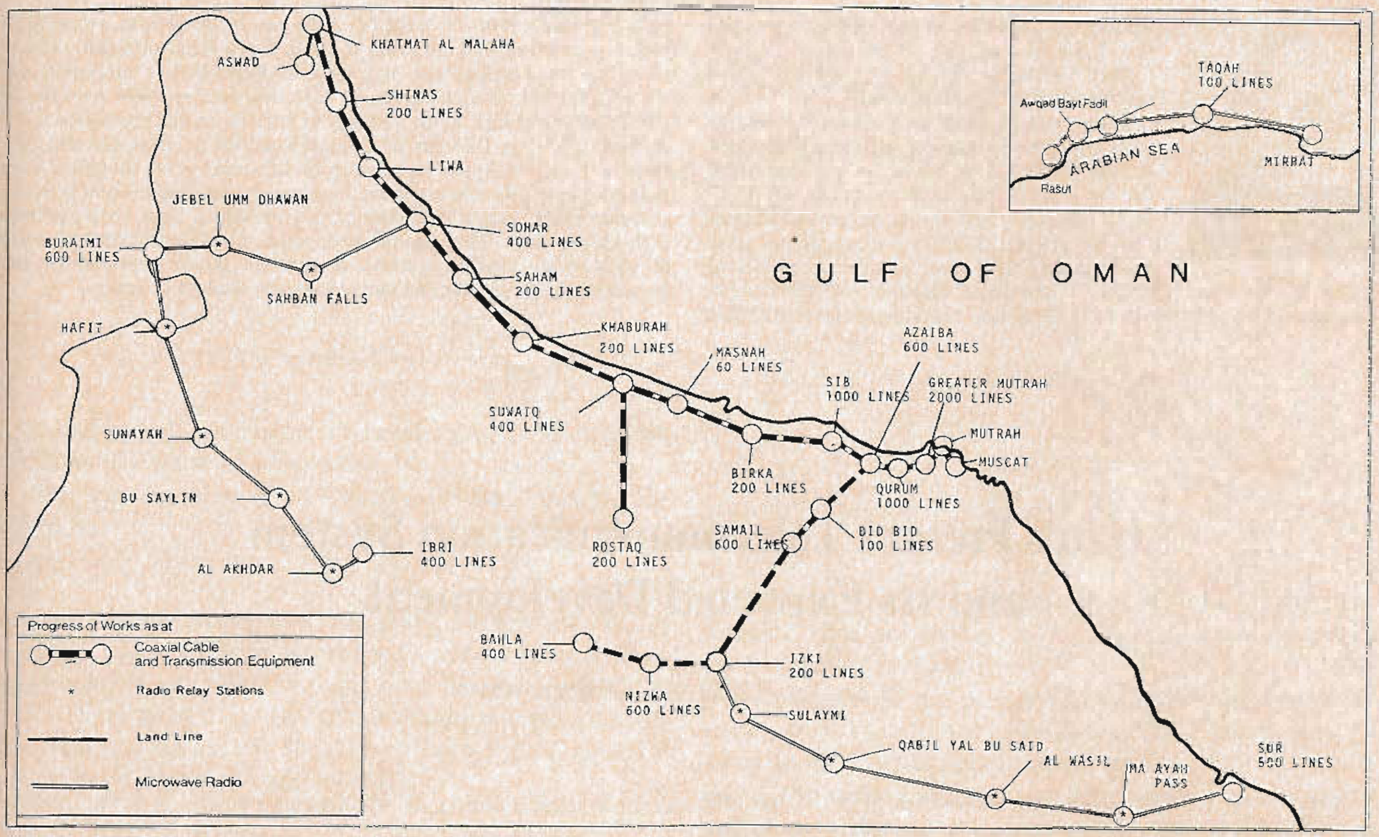

Fig. 2. Sultanate of Oman new telephone scheme.

TABLE I
ESTIMATE OF SATELLITE CIRCUITS (4 kHz) FM CARRIERS

ORIGINATING COUNTRY: Oman REGION: Indian Ocean DATE: 8 September 1975

	1975	1976	1977	1978	1979
TO: ITALY					
Voice		6	8	8	8
Record		1	1	1	2
Total		7	9	9	10
TO: UNITED KINGDOM					
Voice	6	6	7	7	8
Record	1	1	1	1	1
Total	7	7	8	8	9
TO: BAHRAIN					
Voice		7	8	11	14
Record		1	1	2	2
Total		8	9	13	16
TO: UNITED ARAB EMIRATES					
Voice		11	11	11	11
Record		1	1	1	1
Total		12	12	12	12
TO: PAKISTAN					
Voice		1	1	2	2
Total		1	1	2	2
TO: KUWAIT					
Voice			2	3	4
Total			2	3	4
TO: INDIA					
Voice				2	2
Total				2	2
TO: IRAN					
Voice		1	2	2	4
Total		1	2	2	4
TO: GERMANY					
Voice			1	1	1
Total			1	1	1

this time. Various international firms working in Oman, which generate a large portion of the international traffic, are headquartered in Muscat, where at least to places of business, telephone service is more or less adequate. An additional, but as of yet unevaluated, source of traffic increase can be expected as various projects are initiated, such as the development of modern agricultural food-processing plants or the installation of mineral exploitation facilities in the outlying regions of Oman, requiring usage of the new telephone system.

In addition to the satellite communications, provisions are being made for international traffic to be carried on the coaxial microwave system to and from the UAE and beyond. It is also anticipated that traffic from Iran destined to the United Arab Republic (UAR) will transit Muscat and be connected via this facility.

CONCLUSION

Due to the small size of the country and the availability of the foreign exchange from the local petroleum products, OMANTEL has a unique opportunity to build a completely new telecommunications system, and to provide and train a staff of Omani employees fully equipped to operate the system.

The philosophy for the new telecommunications system in Oman is that of a "giant leap into the future," thus bypassing the slow step-by-step progress which occurred in the development of the industrial nations. Within just a few years, the country will benefit from a completely modern system with a fully trained staff to operate it.

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From March 1962 to February 1969, he served as General Manager at Hughes Communications International, where he was responsible for the construction, system testing, and staffing of telemetry and command ground stations for the original SYNCOM synchronous satellites, as well as several earth stations among which the Brazilian INTELSAT station at Itaborai was included. In his capacity as President of ITT Space Communications (ITTSC), from February 1969 to early 1973, he was involved with a variety of projects including the initiation of an in-depth R&D program, responsible for the development of a new double-spherical multiple-beam antenna system. During 1973, he also delivered without penalty 10 INTELSAT standard earth stations to various users. From late 1973 to early 1974, as Director of Communications Satellite Ground Systems at Fairchild Space and Electronics Company, his functions were primarily based on the executive managerial level. Presently a Director at Teleconsult, Inc., a Washington, DC, consulting firm, he is involved with all phases of the technical, economic, and organizational planning of nation-wide satellite systems, such as the Oman international and domestic system and the Indonesia domestic satellite program.

Iran's Present Telecommunication System and Its Expected Development

REZA G. A. TOURZAN, MEMBER, IEEE

Abstract—By the end of the Fifth Plan, March 21, 1978, Iran will have expanded its telecommunication service threefold, it will be providing educational program and television to nearly 75 percent of its population, and it will be well on its way to accomplishing its long-range goal of a totally integrated telecommunication system. It will have graduated telecommunication engineers and technicians from the PTT College of Telecommunications Engineering. Radio and television prodnction specialists will be graduated from the NIRT College which recently ineorporated a Master's Program. It will also have expanded present telecommunication manufacturing capabilities and started new joiut ventures. Where it is now, where it intends to be, and how it intends to get there are described in this paper.

INTRODUCTION

OVER the past few decades, Iran has been able to achieve substantial economic growth through enlightened comprehensive leadership. One of the characteristics contributing to the success of the Iranian economy has been the belief that everything must be worked according to the medium-term economic planning in the form of National Development Programs. Thus, in 1953 came the First Five Year Plan. Iran is now entering the last part of the Fifth Plan.

Over the last ten years, Iran's gross national product has grown from \$6.8 billion in 1964–1965 to \$33.2 billion in 1974–1975. This growth is reflected in the per capita income improvement from \$222 to \$1334 for this period. The Iranian economy expanded at the rate of 17.2 percent/annum over this same time frame. Iran is a vast country, covering 1 648 000 km^2 and includes 34 million inhabitants. Tehran, the capital, has over 4 million inhabitants and is the financial capital of the country. The remainder of the population, apart from a small number of middle-sized towns, is spread rather thinly over the major part of the country, the overall average being 19 inhabitants/km^2. In addition to the oil industry, the work force is primarily devoted to agriculture. However, a determined movement is on to shift the focus toward manufacturing and related industrial occupations.

A few years ago, with the rapid increase in oil revenues came a desire to accelerate the economic and social development of the country. As anyone in the communications industry knows, such rapid economic growth is also accompanied by a record demand for expanded and improved communications. The Telecommunication Company of Iran and other agencies are responding to this need.

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The author is with the Telecommunication Company of Iran, Tehran, Iran.

ORGANIZATION

Recognizing the need for a flexible, dynamic organization to respond to the rapidly increasing demands for communications, in 1971 the Government of Iran created the Telecommunication Company of Iran (TCI) as an autonomous body with separate budgeting and administrative powers. It has its own Board of Directors and is subject to its plenary Assembly of shareholders for policy matters and executive direction. In broad terms, TCI resembles an Operating Company in the Bell System.

NETWORK PHILOSOPHY

Iran presently uses step-by-step telephone switching vehicles, employing an open numbering plan. The switching hierarchy is shown in Fig. 1. The terminal exchange (*TX*), nodal exchange (*NX*), and main exchange (*MX*) levels are designed as star networks to obtain efficient utilization of the exchange trunks. The central exchanges (*CX*) are interconnected as a

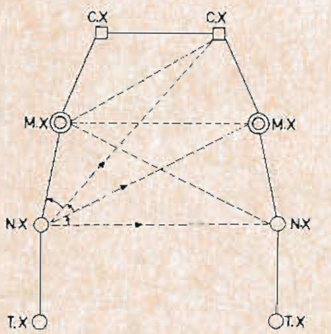

Fig. 1. The switching hierarchy of Iran.

mesh network to obtain the efficiencies associated with high traffic volume between a few points.

The last choice route or "worst case" in this hierarchy would be

$TX - NX - MX - CX - CX - MX - NX - TX$

plus the local exchanges, subscriber plant, and instruments.

Direct route trunking is used wherever economical (high usage concept with overflow going to the last choice route).

The term given to direct distance dialing in Iran is subscriber trunk dialing (STD). The STD network is predominantly composed of microwave radio systems.

SUBSCRIBER PLANT

TCI presently services about 610 000 main stations throughout the country, with approximately 315 000 of these located in the capital city of Tehran. The local subscriber plant is underground cable in the cities and mixtures of cable and open wire in the rural provinces. There are no applications of subscriber carrier in operation today. The present TCI policy is that the company will provide the subscriber facility up to a convenient attachment on the residence or building. The customer is responsible for the house or building wiring and the provision of the instruments. This policy is under review since it makes difficult the control of transmission quality and the administration of the introduction of new features such as touch tone signaling, etc.

Recent studies in Tehran have shown that a large percentage of the customer troubles occurs in subscriher loop plant. This has prompted a massive rehabilitation program to be undertaken by TCI. It is expected to take about two years to complete this work.

SWITCHING

Fig. 1 shows the switching hierarchy of the Iranian network. For the national STD in Iran, an open numbering scheme was selected. It is characterized by the fact that the number to be dialed for a trunk call can be subdivided into the local code and the subscriber call number. The local code for the different terminal exchanges is usually a four-digit number.

Depending on the extent of the network, the snbscriber local call number consists of several digits, e.g., at least four in the case of an 8000 line local network. The numbering scheme was drawn up in line with *CCITT Recommendation, Blue Book*, vol. VI, Recommendation Q11, point 3.

The first digit to be dialed in a trunk call using the STD system is always the traffic discrimination code "0," followed by the local code and the subscriber call number.

Example

A subscriber having the call number 3267 is connected to the terminal exchange with the code 8652. The following is the number for dialing the subscriber from his own terminal exchange: 3267.

To dial him from another local network,

traffic discrimination code	0	8	6	5	2	3267
		CX	*MX*	*NX*	*TX*	subscriber number.

There are seven different charging rates in the network. The charging rates are related to the direct distances between parties involved in the call.

As mentioned, the present switching system is basically step-by-step. The planned expansion program underway introduces about 70 solid-state common-control electronic switchers in the multiexchange cities and 100 reed-type common control switchers in the smaller cities, towns, and villages. Fig. 2 shows the magnitude of this program. It has been designated the 2M59 program, which stands for "2 million main stations by the end of the Iranian year 1359 (March 21, 1981)." Also being introduced for the first time will be automatic message accounting, both on a local (LAMA) and a centralized basis (CAMA). Such features as call waiting, call forwarding, and third party add-on will be available in the areas served by the electronic switchers.

EXCHANGE PLANT

The switching machines in the multiexchange cities are interconnected by cable plant. No PCM carrier is being used in the existing network, but the planned expansion will include about 500 systems. For the most part, junctors or interexchange trunks are on loaded and nonloaded cable pairs of varying gauges.

LONG DISTANCE (STD)

The Iranian equivalent of DDD is subscriber trunk dialing (STD). The modern backbone routes for STD were derived from three basic microwave projects. Fig. 3 shows an overview of these projects. The first was the Central Treaty Organization System (CENTO). This project provided direct communication between Ankara, Turkey; Tehran, Iran; and Karachi, Pakistan. It was started in 1958 and completed in 1965. The total hop length of the system passing through Iran is 2443 km, consisting of 44 hops.

The next project was the 7 Links project, consisting of six through routes. It provides communications between major cities such as Ahvaz, Khorramshahr, Hamadan, Ghazvin,

Fig. 2. Iranian National Network.

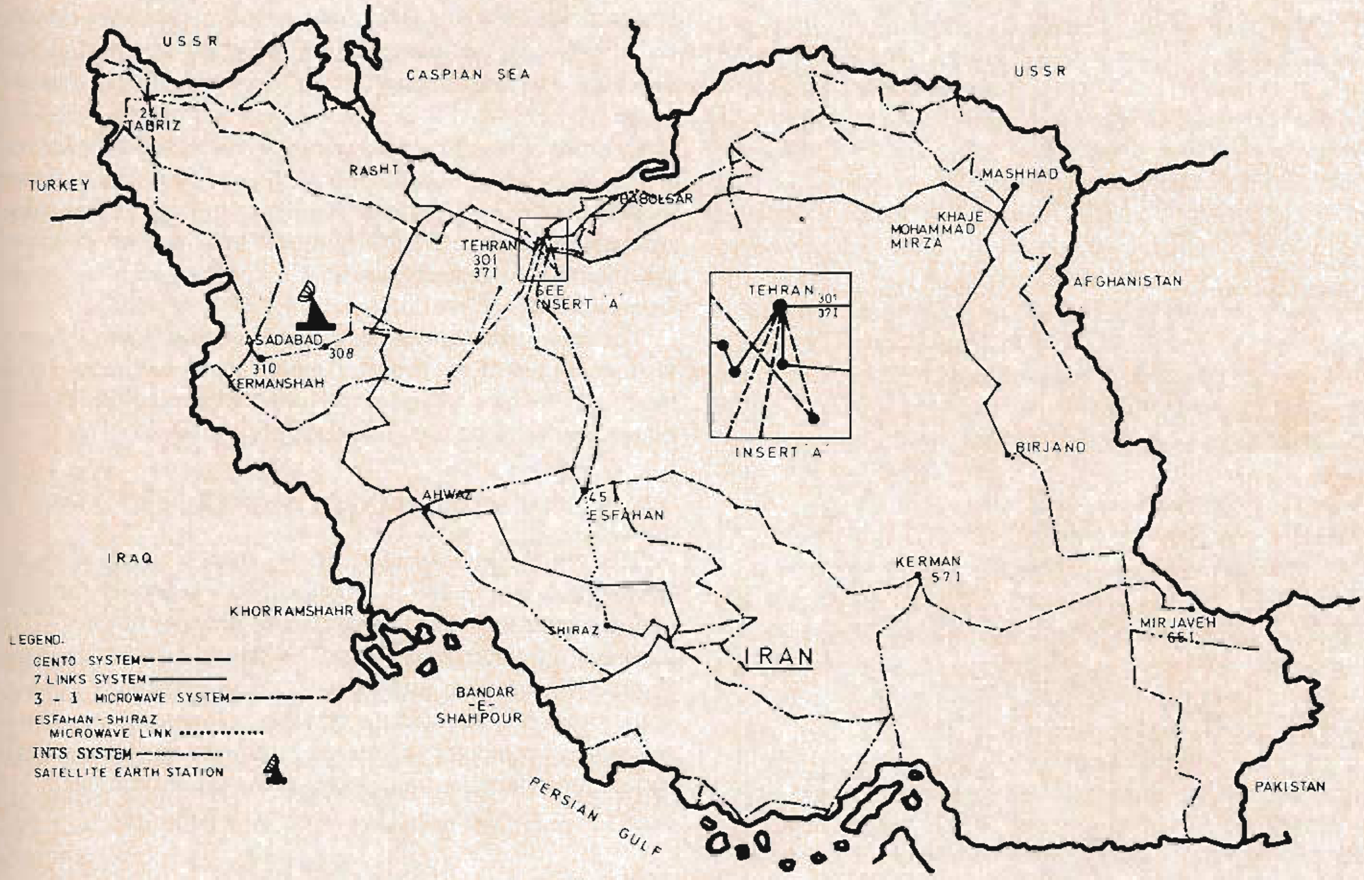

Fig. 3. Existing systems.

Rasht, Babol, Mashad, Birjand, and Tehran. It also links the Persian Gulf area into Shiraz via Bushehr. The 7 Links project was started in 1965 and completed in 1972.

The third project, and one of the largest civilian communication projects ever undertaken in the world, is called the Integrated National Telecommunication System (INTS). It connects 58 major cities and hundreds of small towns and villages. The project was started in 1970 and completed in 1975.

As one might expect, the technology of the hardware of these three projects follows the chronology of the period of installation: tube-type starting with CENTO, and evolving to solid-state with INTS. Table I gives the vital statistics of these projects.

The multiplexing plan calls for 365 terminals for cities and military sites. These vary in capacity from 24 to 1200 channels. Table II gives a general breakdown of the quantities of each. At the completion of the present expansion program, there will be over 2600 supergroups or a total of over 150 000 channels available nationwide.

On the international side, Iran is presently accessing two Intelsat satellites. In the Indian Ocean region, service commenced on August 20, 1975. A 100-ft dish fully steerable antenna with cooled parametric amplifier is used. The ground station is located approximately 400 km from Tehran and approximately 63 km from Hamadan. The same site is used for the Atlantic Ocean satellite antenna. The Indian Ocean scheme occupies a 5-MHz band and provides 60-channel capacity, which may be expanded to 72. The United Kingdom, Japan, Germany, Italy, the People's Republic of China, France, the United States, and Switzerland are the major countries accessed over these facilities.

The Atlantic Ocean satellite service commenced in October 1969. The antenna works with two carriers, a 2.5-MHz 36-channel capacity direct to the United States and a 5-MHz expanded carrier with 72-channel capacity covering European countries. Plans are being drawn up for installing a third antenna in Assadabad to work with the Atlantic Ocean satellite and to be used for high-capacity routes to Europe and the United States.

An Iranian SPADE terminal with capacity for 24 channels has already been installed and service is imminent as of this writing. Iran is also presently studying the possible use of a domestic satellite for educational, entertainment TV, and rural communications.

INTERNATIONAL AUTOMATIC TELEPHONE EXCHANGE OF TEHRAN

Nearing completion in Tehran at the time this was written was a fully automatic international telephone exchange. It was expected to be in operation by March 1976. It includes such features as register control, four-wire switching path, operator interventiou, automatic message accounting, CCITT No.5 signaling, and many others.

The exchange will be capable of direct dialing over 400

TABLE I

Contract signed:	January, 1970
Project completed :	December, 1975
Number of cities connected :	58
Number of installation sites :	549
Number of link kilometers :	14,000
Number of voices channel kilometers:	15 million
Number of channel ends :	14,207
Frequency band :	6 GHZ (main routes)
Channel capacity :	1200 ch. (main routes)
7 - LINKS	
Project started :	1965
Project completed :	1972
Number of sites :	79
Number of link kilometers :	3563.9
Number of voice channel kilometers :	471566.5
Number of channel ends :	1007
Frequency band :	6 GHZ
Channel capacity :	960 ch.
CENTO	
Project started :	1958
Project completed :	1965
Project mission :	direct communication between Ankara-Tehran-Karachi
Length of the system :	2443.27 km (Iran)
Number of stations :	45 (Iran)
Frequency band :	1.7 - 2.3 GHZ
Channel capacity :	600
Number of channel ends :	199 (Iran)

TABLE II
MULTIPLEX TERMINALS

Channel Capacity :	24	120	300	600	960	1200
# of Terminals :	105	107	59	36	39	19

international circuits to the United States and Canada, most of the major cities in Europe, Japan, and the Middle East countries.

It is planned to have direct trunks to each of the National Central Exchanges (*CX*) for efficient distribution of incoming and outgoing ISD traffic.

NATIONAL IRANIAN OIL COMPANY (NIOC)

The National Iranian Oil Company has its own private microwave system which practically parallels its pipeline network.

There are six major sections making up over 3400 km of microwave radio. There are 94 repeater stations in the network, 14 of which are the passive type. The system is operated in the 7-GHz band.

NIOC shares its network with all of its affiliated oil companies, as well as Tavanir, the Iranian electric power generation and distribution company, and NIRT, which uses part of the backbone for distributing Second Program TV to various areas.

In addition to voice communication, NIOC has an extensive telemetry system for supervision and command control from a centralized computer-controlled location. UHF Mobile radio base stations have interconnect capability with the microwave radio system, so that no part of the pipeline area is in a communications blindspot.

The microwave system is divided up among seven maintenance centers. Each repeater station along the backbone is monitored by two independent maintenance centers, so that no part of the backbone route can be isolated.

NATIONAL IRANIAN GAS COMPANY

The NIGC has a smaller, private microwave network as compared to NIOC, and it is used almost exclusively for their internal communications needs. It also operates in the 7-GHz band and, for the most part, has 300-channel capacity. It spans about 1500 km from the south of Iran to the Russian border, with about 38 intermediate repeater stations. It also has a centralized computer command and control telemetering system for supervision and control of the various stations.

SPECIAL SERVICES

Radio and TV Broadcasting

1) Radio Broadcasting:

AM: There are presently 36 medium- and short-wave transmitters operating in 18 major cities in Iran with a total output of 9960 kW. By the end of the Fifth Plan, this will increase to 16 258 kW.

FM: In March 1973, FM transmission in Iran was limited to the three cities of Tehran, Shiraz, and Kermanshah. However, by March 1975, the number was increased to 19 stations in 11 cities, with at least one FM program reaching 9 million listeners (28 percent of the population), and 7.8 million listeners having access to two or three FM programs. The total number of FM transmitters was to have reached 40 by March 1976.

2) TV Broadcasting: At the end of the Fourth Five Year Plan, there were 91 TV transmitters broadcasting the First Program, reaching 50 percent of the population. Sixty-one TV transmitters were installed in the first two years of the Fifth Plan, which increased the coverage by First Program to 64 percent. The slow increase in coverage is mainly due to the low population density outside major cities.

The Second Program is presently being broadcast in six major cities, covering 24 percent of the population.

By March 1976, the First Program was to have reached 75 percent of the population via 290 transmitters, and the Second Program was to have reached 30 percent of the population via 25 transmitters.

Alternative methods of total TV coverage for educational purposes are under study, with special emphasis on the possibility of the use of domestic satellites for this purpose.

National Iranian Radio and Television (NIRT) is also in the process of installing ground facilities for two balloons to be flown over two of Iran's widely dispersed and migratory populated regions (Persian Gulf district and Baluchestan). Each balloon will cover a total area of 125 000 km^2 and will be fixed at a height of 4500 m. The balloons will each be equipped with UHF and VHF transmitters for TV and FM radio broadcasting. The ERP power of the TV transmitrers will be 1 kW and that for FM transmission will be 100 W.

Telex/Gentex Service

In March 1973, the end of the Fourth Five Year Plan, there were 600 telex subscribers and 235 teletypes for public use, connected to a mechanical automatic telex network. Installation of an entirely computerized telex/Gentex system started at the beginning of the Fifth Plan, and the first exchanges have been cut over with a total capacity of 2500 subscribers. After the completion of the first phase of this project in January 1976, tbe system was to be able to connect up to 6000 subscribers and 390 Gentex offices throughout Iran. In the second phase, which is due for completion in the Sixth Plan, the system will serve 10 000 subscribers and 800 Gentex offices in 17 major cities, plus all other towns and points with a population of over 3000 which are situated in the vicinity of these major cities.

Mobile Radio Telephone

TCI is presently evaluating proposals for a computer-controlled fully automatic mobile radio telephone system with an initial capacity of 3000 subscribers covering the Tehran area. The system is being planned so that the Tehran system can be expanded in the next ten years to cover 10 000 subscribers in Tehran and all the major cities.

Training and Research

Besides the universities and colleges that train electrouic engineers and perform some research, there are also a number of colleges and training centers set up with the sole purpose of training telecommunication specialists. PTT established the first technician training center almost 50 years ago (1927), but the PTT College of Telecommunication Engiueering was set up in 1942 with an expanded objective of training engineers and technicians needed by the Ministry of PTT. The school presently graduates 30 engineers and 300 technicians per annum in a number of telecommunicaion specialities. NIRT has its own college, and for a number of years has been training radio and TV production specialists. In October 1975, the college started a Master's Program in Telecommunication Engineering.

It has been the policy of the Iranian Government that with every major telecommunication project, the contractor has had to set up a specialized training center to train Iranians in order to maintain and operate the system, and these centers have continued to train Iranians ever since. The major training centers in these categories are CENTO Microwave, EMD Step-by-Step Local and STD Switching, 7 Links, and INTS Microwave Network schools.

The Telecommunication Company of Iran is presently in the process of analyzing its manpower and training requirements in order to integrate all of the training centers, with a view to preparing the cadre of Iranian engineers and technicians to maintain and operate its future expanded network.

The only major research center in Iran, besides the universities, involved primarily in telecommunications research is the Iranian Telecommunication Research Center. It began its research in 1972 and has been active in practical research in the areas of microwave systems, telegraphy, carrier telephony, radio communication, radio broadcasting, overhead lines, and cables and switching.

Manufacturing

Besides the private industries' manufacturing capacity of 230 000 TV sets and 140 000 radios annually, there are also three privately owned cable manufacturing plants that manufacture mainly electrical cables and telephone cables up to 200 pairs. Another cable manufacturing plant is being installed with the sole purpose of manufacturing telephone cables with private and foreign participation. There are presently four companies manufacturing telecommunication equipment in Iran nnder license; they are the following.

1) Iranian Telecommunication Manufacturing Company (ITMC): Set up in 1968, this is 70 percent Iranian-owned with 30 percent German participation. It is presently manufacturing 80 000 lines of step-by-step switching equipment and 120 000 telephone sets annually. ITMC is in the process of expansion, and by 1977, it would increase its annual production to 120 000 lines of switching equipment and 200 000 telephone sets.

2) Iran Nippon Electronic Company (INEC): This was set up in 1973 with 70 percent government and 30 percent Japanese participation. It is presently manufacturing carrier and multiplex equipment, and is expanding its product range to radio relay and PCM equipment in the near future.

3) Telephone Sazi Iran: This has 33 percent Iranian aud 67 percent foreign participation. It is at present manufacturing 120 000 telephone sets annually and a limited number of manual switchboards. The company is setting up a second plant and plans to manufacture up to 200 000 telephone sets per annum, and outside plant accessories such as cabinets, distribution boxes, protectors, etc.

4) Iran Electronic Industries (IEI): This is a fully government-owned company. It was set up in March 1973 with the main purpose of manufacturing and doing research in the field of electronics and electrooptics for military and civilian use. The company has so far obtained licensing agreements and started manufactnring military electronic equipment, but it is hoped that by 1985, IEI would also penetrate into civilian communication research and production.

The Government of Iran is presently negotiating for setting up a plant that would start the manufacturing of stored program-controlled telephone switching equipment by March

1978. This could manufacture 500 000 lines of switching equipment annually after 1978.

FUTURE DEVELOPMENTS

TCI has contracted a major telecommunication corporation with extensive experience in engineering a totally integrated network, i.e., civilian, governmental, industrial, and military needs. Their task is to study the present systems serving these various organizations, and develop a proposal for integrating the systems to obtain the benefits of economy of scale, system engineering, and the like. The study is due to be completed and the proposal made within a year. If the proposal is accepted, it will set the course of TCI over the next 10 to 15 year period. The study is to include every facet of communication technology and media, and it is to be geared to satisfying all existing and future communications demands of Iran.

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Global Scope at the National Level: The ITU's Contributions to Telecommunications Development

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Abstract—The International Telecommunication Union's (ITU) work that is oriented towards the needs of developing countries is described. This work is explained as one of two kinds of technical cooperation; the other kind corresponds to the ITU's traditional function as coordinator and standards-maker for international working of telecommunication services. It is shown how these two kinds of technical cooperation both aid each other and compete with each other for funds, top-level organizational attention, and provision of expert manpower. The growth and diversity of cooperative activities for the benefit of developing countries is reviewed in some detail. Numerous examples of handbook-writing and special national or regional projects are given. It is concluded that the ITU exhibits two faces, one directed toward the highly developed country, another toward the developing country in need of help. Maintaining a judicious balance in support of these two personalities represents a challenge to the ITU as a whole, and to its Permanent Organs in particular.

I. INTRODUCTION

THE International Telecommunication Union's (ITU's) direct predecessor organization was founded in 1865 by 20 European states. Its purpose was to assure compatibility for the operation of the telegraph service across national borders. Since then, with 148 member states in 1975, the ITU has become the world's coordinating and catalytic agency for the development of telephony, telegraphy, data communications, radio and television broadcasting, and space/satellite communications for every conceivable use. The ITU's technical cooperation in the areas of standardization, planning, and administration must be shared by all countries of the world—developed and developing.

The relentless advances of technology and the services it makes possible create a special complexity for the ITU's tasks of cooperation. As one aspect, the technologically advanced developed countries face a continuous challenge adapting each other's technical solutions to common agreement so that worldwide services can function. An example is international telephone dialing. Another aspect is the extension of these advanced services and the associated new technology to *all* countries, in the interest of a truly worldwide telecommnnications network. This aspect grows rather smoothly out of the first; it focuses on development of uniform telephone, data, and other

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services so that the business of message exchange may function internationally as if there were no differences of national development. A third aspect, though related to the worldwide extension of networks, focuses iustead on the condition of telecommunications services and technology in the developing countries. Under this aspect, technical cooperation takes the form of projects and missions directed to the specific developmental needs of one country, a group of countries, or a whole geographical region.

The present paper deals in some detail with the second and third aspects, both of which involve telecommunicators from developing countries actively for the purpose of advancing the state of telecommunications in their respective countries. However, the reader should not be led to assume that the first aspect, i.e., standardization of new services and technology, is entirely a marter for advanced countries only. Some developing countries are contributing to the expertise on these questions. The important point we wish to make is that the initiative generally rests with the operating organizations and laboratories in advanced countries, and that the special needs of developing countries are incidental rather than dominating in the work of the standardizing study groups [1]-[3].

II. PURPOSES AND STRUCTURE OF THE ITU

A. Purposes

The purposes of the Union as defined in the Convention are: to maintain and extend international cooperation for the improvement and rational use of telecommunication of all kinds; to promote the development of technical facilities and their most efficient operation with a view to improving the efficiency of telecommunication services, increasing their usefulness and making them, so far as possible, generally available to the public; and to harmonize the actions of nations in the attainment of those common ends [4].

B. Structure

The ITU organizational structure is shown in Fig. 1.

III. DEVELOPING COUNTRY POLICY-MAKING IN THE ITU

A. The Growing Voting Strength of Developing Countries

Membership in the ITU has almost doubled in the past 25 years (see Table I). Prior to World War II, the less industrially developed ITU member countries were much fewer in number and were guided by the advanced country policies. In the 1970's, however, the developing countries make up about 80 percent of the membership. A full understanding of the significance of this change requires taking into account the emergence of the United Nations. The ITU became one of the UN Specialized Agencies in 1947 and as such is linked to the UN in many ways affecting policies and administration. For example, the UN emphasis on the problems of developing countries is apparent from Opinion 2 passed at the 1973 Plenipotentiary (Málaga-Torremolinos) titled, "Favorable Treatment for Developing Countries." It pleads "that developed countries should take into account the requests for favorable treatment made by developing countries in service, commercial or other relations in telecommunications, thus helping to achieve the desired economic equilibrium conducive to a relaxation of present world tensions."

More and more at ITU Conferences, including the Plenary Assemblies of the two consultative committees CCIR and CCITT, delegations of many developing countries have rallied around objectives and policy issues *en bloc.* Such position-taking lends itself to broad issues of general policy, and to narrow choices of one resolution or one candidate over another. These are issues that either can or must be decided by voting. The bulk of the ITU's study group work on technical and operating agreements is not of such nature. As has been elucidated elsewhere [5], discovery and universal observance of such agreements depend on voluntary acquiescence in a compromise that avoids the confrontation of winners versus losers. As long as technical standardization and associated agreement-making functions remain among the principal purposes of the ITU as a whole, the relative autonomy of the Consultative Committees provides an organizational framework best suited for these purposes. But the overall program of the CCI's and most other ITU activities are subject to national policies and voting.

Against this policy background, national representation in the ITU has three targets: 1) matters of overall policy, purposes, budgets, and executive management of the organization; 2) pursuit of technical and operational agreements for worldwide compatibility and service performance to uniform standards; 3) the allocation and regulation of shared resources, e.g., the radio frequency spectrum [6], [7]. Target 1) is attained at the Union's intergovernmental conferences, to wit: a) Plenipotentiary conferences, for revising the Convention, establishing budgetary limits, and electing top officers; b) annual Administrative Council sessions, for reviewing budgets, management functions, programs of the technical committees, and technical cooperation; c) in conjunction with target 2), Plenary Assemblies of the CCI's and meetings of the Plan Committees; d) in conjunction with target 3), World or Regional Administrative Conferences, for the allocation and assignment, as applicable, of the radio frequency spectrum.

We shall briefly review the trend of developing country orientation for these four types of conferences.

B. Developing Country Needs Articulated at Plenipotentiary Conferences

The ITU has had an opportunity for revising its Convention every seven years or so. During the past 20 years, conventions have been adopted in 1952 (Buenos Aires), 1959 (Geneva), 1965 (Montreux), and 1973 (Torremolinos). The trend may be measured by the number of provisions and resolutions of the Convention that are concerned with developing countries (Table II). The 1952 Convention made two broad references to developing countries: a Resolution regarding ITU cooperation with the UN Technical Assistance Program, and a Resolution titled, "Linking of Certain Regions to the World Telephone Network." In the latter, particular reference is

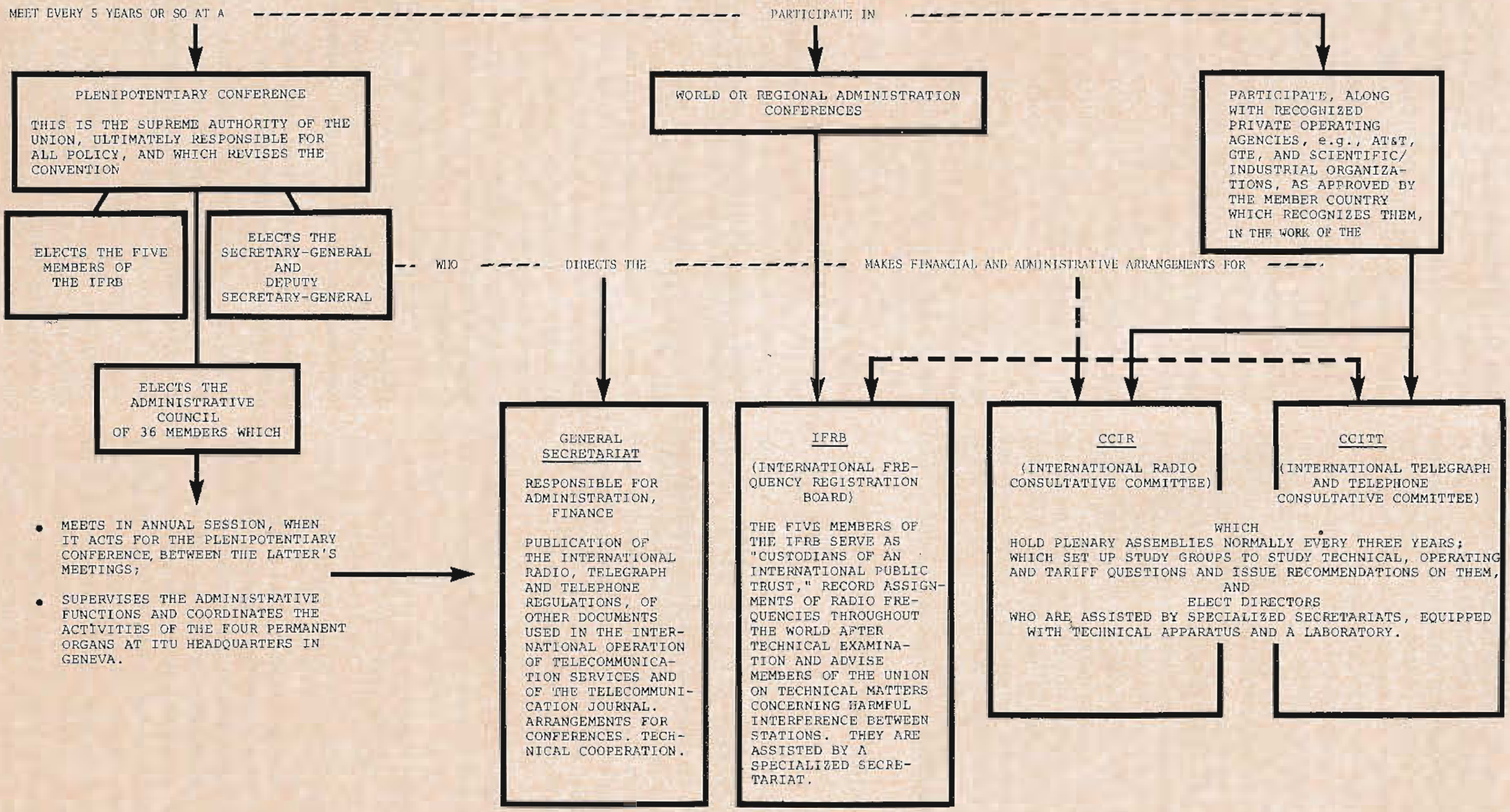

Fig. 1. Structure of the ITU.

TABLE I
ITU PLENIPOTENTIARY STATISTICS

Year	No. of Members[a]	Administrative Council Members[b]	ITU Annual Budget (Swiss Francs)[c]
1947	73	18	4 000 000
1952	90	18	6 000 000
1959	96	25	9 000 000
1965	129	29	18 000 000
1973	140	36	35 000 000

[a] Exact number of members is subject to membership status and official accession timing.
[b] The Administrative Council is the ITU's Governing Board.
[c] Budget figures rounded, first period year.

made to the technical and economic problems associated with this task, and the Technical Committees are instructed to undertake suitable joint studies. The 1959 Convention incorporated several specific measures for the benefit of developing countries. It added to the Purposes of the Union, under Article 4, an objective to:

"... foster the creation, development and improvement of telecommunication equipment and networks in new or developing countries by every means at its disposal, especially participation in the appropriate programmes of the United Nations; ..." [4].

In pursuit of this objective, successive Plenipotentiaries have adopted an increasing number of resolutions. One of the resolutions introduced at Málaga-Torremolinos in 1973 is concerned with the training of qualified technical personnel as a major problem facing developing countries (Resolution 23). Another resolution appeals to the developed countries to consider the needs of the developing countries in the supply of qualified experts, to be recruited by the ITU for Technical Cooperation (Resolution 22). The *Resolution* is a decision device, by which an objective may be placed on record without, at the time, requiring the depth of inquiry appropriate to a firm commitment of funds and manpower. Resolutions can be adopted in full awareness of a lack of unanimity, whereas the ITU's definitive actions are taken by unanimous decisions (sometimes with an unhappy but acquiescent minority dissent). The above-cited resolutions have laid the groundwork for manifold activities of the General Secretariat, under whose direction a Technical Cooperatiou Department was established in 1960.

Also since 1959, the two consultative committees CCIR and CCITT are charged to

"... pay due attention to the study of questions and to the formulations of recommendations directly connected with the establishment, development and improvement of telecommunication in (new or) developing countries in both the regional and international field, ..." [8].

Attached to the Convention was a Recommendation, spelling out the tasks of the CCI's. This general policy has provided the platform for several courses of action, as discussed later in this paper.

TABLE II
PROVISIONS AND RESOLUTIONS OF THE ITU CONVENTION CONCERNED WITH DEVELOPING COUNTRIES

Year	Number of Provisions[a]	Resolutions: By Number	Resolutions: Percent of Total
1952	0	2	6
1959	6	9	25
1965	8	14	30
1973	9	11	31

[a] Inclndes Basic Provisions and General Regulations.

C. Administrative Council Sessions

Again referring to Table I, we note that the membership of the Annual Administrative Council has grown to 36 since 1973. The increased membership is a specific outcome of developing countries' growth in numbers and desire for a direct voice in the executive management of the Union. At the annual sessions, typically of three-weeks duration, the program in Technical Cooperation takes up a significant part of the Council's time. The Secretary General presents a detailed account of the Union's activities with emphasis on the Technical Cooperation Department [9]. The report lists, for developing countries, each temporarily employed expert by country of origin and country of destination, type of project, etc. The cost of these particular activities is, in principle, recovered from the United Nations Development Program (UNDP).

D. World and Regional Administrative Radio Conference

The phenomenal expansion of the radio frequency spectrum's technical capabilities is well known to electrical and electronic engineers at large. What is less widely understood is the kind of Parkinson's law of radio telecommunications, by which new services and expanded applications are, at any time, ready to match the newly expanded capabilities. At ITU radio conferences, this Parkinson's law becomes apparent, and its particular interpretation takes a national color. Participating in these conferences where allocations to services, and in the case of the broadcasting service, assignments of actual station frequencies and transmitter powers are made, developing countries are less likely to take action en bloc than on other occasions. The reason for this is that each nation would like to control the uses of the airwaves over and in its territory. Some of the developing countries have more ambitious plans than others; and of course, some have geographical situations that give rise to more critical interference problems with neighboring countries.

Two examples may be mentioned. For both examples we choose India's problems because of their magnitude (national population ca. 580 000 000 in 1975). At the World Administration Radio Conference of 1971, India requested frequency allocations that would be technically and economically most attractive for the realization of its Satellite Instructional Television Experiment (SITE) project [10]. The plea was specifically substantiated as a need for the country's social development. Nevertheless, other developing countries failed to support this request, particularly several of India's neighbors. The request also conflicted with uses of the same part of the spectrum already made by most advanced countries [6].

Four years later, at the Broadcasting Conference for World Regions 1 and 3 (Europe, Asia and Oceania, and Africa), India presented its requirements of over 1200 transmitter frequencies in the available 120 channels of the Standard Broadcasting Band (525-1605 kHz). Taken over a total 10 000 requirements, this was roughly equivalent to India's share of the total population in the two world regions. In justifying the magnitude of its plans, the delegate of India stated, *inter alia*:

> "In these countries (Europe), Mr. Chairman, MF (Medium Frequency) broadcasting is au alternative means of broadcasting, unlike Asia and Africa where broadcasting is the only means for reaching the masses. The European countries could, therefore, make more concessions to come to an agreement for otherwise an agreed plan will be difficult fo find... India's broadcasting network has to cater for the languages and dialects besides radiating national programs, programs for schools, rural and urban areas and programs for farmers, women and others. We do have a formidable program and the requirements we have submitted are nowhere near the optimum required" [11].

It is hard to tell whether this rationale was very persuasive with many of the European countries, whose delegates spent the seven weeks competing with each other for every station frequency and transmitter power in their respective territories. At the conference's end, India did emerge with close to 1000 assignments, about one-third of which are in the three channels set aside for low power (1 kW and less) transmission. This number allows for an expansion by several times over the transmitters actually operating in 1975. Therefore, India's broadcasting development plan may be considered successfully secured in a competitive, partly hostile situation [12].

These examples are given in order to highlight the fundamental difficulties of accomodating a developing country's specific requests when the required cooperation involves concessions in the allocation of a scarce, internationally sbared resource.

E. Developing Countries' Activities Giving Direction to the CCITT and CCIR

These activities are a logical consequence of the developing countries' position at the receiving end of technology. Their aetive participation in a CCI conference concentrates on issues associated with bridging of the technological gap. Suceessive conferences since 1959, witnessing increasing participation by developing countries, have adopted a number of measures specifically tailored to the needs of the developing countries [13]. These fall in two categories: 1) origination of specific questions for study by the CCITT and CCIR; and 2) formation of Groups or Workiug Parties entirely dedicated to the study of such Questions. These activities, of considerable interest to practicing engineers, are discussed in the next section.

IV. ORIGINATION OF SPECIFIC QUESTIONS

A. Evolution of a Pattern

During the 1950's, separate regional initiatives had given birth to the Plan Committees for Asia and Africa. The Latin American region was recognized in the 1959/1960 time frame. These joint CCIR/CCITT committees, administered by the CCITT, plan the expansion of the international network in terms of traffic and circuit forecasts. It seemed natural to many developing countries that this activity could be combined with the formulation of questions of specific interest to developing countries. Therefore, the terms of reference of these Plan Committees were expanded so as to stimulate questions and channel them to the CCI's for study. Starting with the first Plan Africa meeting in 1962, the African, Asian, and Latin American Plan committees have posed two types of questions:

1) Requests for international standardization (recommendation in ITU parlance) of lower cost transmission systems than those recommended for the typical heavy-use developed-country long-distance service.

2) Requests for tutorial information, suitable for engineering and operating personnel training, engineering management, and decision making in the choice of systems or equipments.

Questions of category 1) find their way onto the program of the most nearly competent study group. Questions of the tutorial category 2), however, are more difficult to handle. Depending on their scope and expected final outcome, they may be placed onto a study group's program or they may require the setting up of a separate group. Both avenues have been chosen.

B. Questions Accepted for Study by the Regular Study Groups

There have been several questions concerned with so-called low-capacity thin-route low-cost systems, both for radio and cable transmission. The CCIR and CCITT study groups competent for the study of such systems have had great difficulty in responding. This is due to the concern for maintaining worldwide standards of transmission quality and circuit availability. It is very diffieult to effect substantial cost advantages in transmission equipment of limited channel capacity, without accepting relaxation of normal performance standards. On the other hand, it is possible to effect significant engineering economies in systems planning and installation. Economies may also be possible by judicious choice of eqnipment complements selected from the family of standardized systems. Therefore, opportunities for satisfying these questions are more likely to be encountered in systems engineering information and related data than in the design of special systems.

In effect, then, most if not all the questions formulated by the developing countries have gravitated towards the tutorial category. At the CCITT's second Plenary Assembly, end of 1960 at New Delhi—the first held outside Europe— a number of documentary questions were given to several study groups. Among these, the question for the "Design of National

Automatic Telephone Networks" had a particularly fortunate outcome. Placed onto the agenda of the Study Group for Signaling and Switching Systems, it became the concern of a Working Party chaired by an expert of the Australian Post Office administration. This Working Party was able to produce a Manual for publication in the 1964/1965 time frame. The Manual was well received and it established a pattern. It has proven that tutorial questions can be answered if separated from the regular study group's line of work. Not all such questions fared equally well. The question seeking comprehensive information on the Planning of Open-Wire Lines has remained on the Transmission Systems Study Group agenda for several study periods, without resulting in a publication. One of the problems was to find a strong enough support from volunteers to do the job, considering that open-wire systems have rapidly decreased in importance since 1960. This qnestion is finally being answered by impending publication of a definitive *Handbook on Open-Wire Construction and Utilisation for Trunk Purposes,* probably in 1976, due to the dedicated efforts of an Australian expert. Other handbooks created within regular study group activities include a booklet on *Preservation of Wooden Poles* and a Handbook on *Pressurization of Telecommunication Cables.* Efforts concerned with the problems of Earthing, on the other hand, crossed the study territory of several study groups. A Joint Working Party was set up, and nnder its guiding umbrella a new *Handbook of Earthing* has been prepared, mostly during the 1968-1972 period.

C. Formation of Special Groups or Working Parties

The Manual *National Telephone Networks for the Automatic Service* demonstrated the merits of setting up a Working Party for the purpose, partieularly where the required expertise might have to be drawn from the sphere of competence of several study groups. The 1964 CCITT Plenary Assembly therefore approved the creation of five Specialized Autonomous Working Parties, designated *GAS* in accordance with French nomenclature [14]. They are listed in Table III. Note that only two of these GAS groups have been eontinued through the current CCITT study period, which extends from 1973 through 1976.

Planned additions to the coverage of the GAS 1 and GAS 2 Manuals have now been allocated as Questions to two study groups, concerned with Telephone Transmission Quality and Telephone Circuits, respectively. An expert of the U.K. Post Office, who became chairman of one of the study groups, took combined responsibility in hand. This work has culminated in a new Manual of several hundred pages, to be published in the 1975/1976 time frame. Title of the Mannal is *Transmission Planning for Switched Telephone Networks.*

In contrast to this trend, the work of Specialized Autonomous Working Parties GAS 3 and GAS 5 has been reauthorized at successive CCITT Plenary Assemblies. Both these GAS groups have received considerable direct attention of delegates from developing countries. GAS 3 was chaired until recently by the Director of Telecommunications for Morocco, and one

TABLE III
THE GAS GROUPS AND THEIR MANUALS

Group Number	Title of Manual	Remarks
GAS 1	National Telephone Networks for the Automatic Service	Inactive since 1969
GAS 2	Local Telephone Networks	Inactive since 1969
GAS 3	Economic and Technical Aspects of the Choice of Transmission Systems	Active through 1976
GAS 4	Primary Sonrces of Energy	Inactive since 1970
GAS 5	Economic Studies at the National Level in the Field of Telecommunications	Active through 1976

of the vice-chairmen represents Mexico. GAS 5, chaired by an expert of the French Ministry of Communications, has vice-chairmen representing Argentina and Nigeria, respectively.

The story of GAS 5 *Economic Studies at the National Level in the Field of Telecommunications* is particularly interesting because of its venture into economic studies and the province of business management of a national telecommunications organization. It is self-evident that many developing countries would seek guidance and, if possible, standards of management decision making, in the difficult task of building their telecommunications infrastructure. The terms of reference for this group have been expanded at successive Plenaries, so that during the current period, 1973-1976, substantial new texts on planning for telecommunications growth and personnel policy have been prepared. Interpreting the desires of several developing countries, it can be envisaged that GAS 5 will continue to expand and complete its coverage of such subjects as cost accounting and general management of a telecommunications enterprise.

The work of GAS 3, *Economic and Technical Comparison of Transmission Systems,* produced a comprehensive manual on wireline and radio transmission systems of circa 1000 pages, first published in 1969. Drafting of these texts was a truly worldwide endeavor, with experts from some 15 nations contributing. Because of the rapid growth and increasing diversification of transmission systems, both in technology and applications, snch a Manual would become outdated in a few years time. At the time of first publication, two important new system categories had to be given negligible treatment, because of the preliminary status of technical data about them. These are the family of PCM systems and satellite systems. It must be kept in mind that a tntorial GAS group is not the place to bring about world standardization of new systems. This task belongs to the regular study groups and constitutes their principle reason for existence. Thus, if progress in the study groups appears slow or insufficiently unanimous, as has been the case for the PCM system standardization, then the GAS group cannot make believe that standardized systems are here to be described and compared.

In the two new areas, the work in the CCIR (satellite systems) and CCITT (PCM transmission systems) has become more definitive since 1969, so that rhe GAS 3 Manual is undergoing substantial expansion in these two areas. Further at the 1972 Plenary, a group of national delegations, predominantly but not exclusively from developing countries, initiated a request for GAS 3 to provide technical/economic comparison type information about Domestic and Regional Satellite systems.

In 1974, the telecommunication administrations of the Latin American countries formulated a joint inquiry into the problems of *Rural Telecommunications.* As a result of their requests and proposals, this complex subject has been added to the study program of GAS 3. The official mechanism for accomplishing this expansion of work authorized at Plenary Assemblies gives an interesting illustration of the ITU's flexibility. The Convention provides in Number 308 (Torremolinos) that other than at Plenary Assemblies, Questions may be set for study if requested or approved by at least 20 Members. This procedure was used in the case of Rural Telecommunications and resulted in GAS 3 receiving this new Question for study approximately 18 months prior to the next Plenary Assembly.

D. Participation in the Working Groups of the CCITT

The CCITT study groups formulate the questions and work out their solutions. The ensemble of these questions is approved at Plenary Assemblies, convening in three- to four-year intervals. Questions originated by developing countries are then added to this list. Progress in the study of these questions depends on voluntary assignments taken by people with the necessary expertise. These people are, by definition, key experts of high value in their respective organizations at home. Their time is volunteered for work as deemed necessary for the good of their respective organization's own conduct of operations. Most CCITT questions seek worldwide agreements on technical characteristics of operating systems. The need for compatible operation of the world's telephone, telegraph, telex, data, and broadcast networks justifies the manhours spent in CCITT study groups.

By contrast, time spent on tutorial questions may not necessarily seem equally justified as seen by an organization that can provide the answers. Such questions seek information in more depth and detail than an industrially developed organization is used to making public. Too much published detail can become an impediment to changes. On a new system, when does field experience justify a finalization of specifications and practices? As a consequence, work on developing countries' tutorial type questions can go principally against the grain of the industrially strong organizations. There must be other incentives for committing scarce manpower to this work.

Indeed these incentives are built into the same industrial system. National industries compete for the business with developing countries, and better informed clients can make more satisfied customers. Clients comparing competitive information can be confused by too much divergence or outright contradictions. In the worldwide telecommunications market, suppliers and users alike now accept as beneficial a state of affairs where there is a minimum divergence of applicable specifications and descriptions.

By similar reasoning, the advanced countries' telecommunications' organizations providing international services are interested in dealing with technically well-prepared partners at the far ends of their growing international traffic network. Therefore, organizations such as AT&T, Communications Canada, and the German Bundespost assign some value to the improvement of engineering capability in their counterpart African, Asian, and Latin American organizations.

E. Insufficient Dialogue

Appeals to the developing countries for more direct participation in CCITT study group work have paralleled requests by some developing countries for scheduling meetings in a manner that makes their participation economically more palatable. Nevertheless, this dialogue has been infrequent and inadequate. Why is this so?

Only a few developing countries can afford to send experts to a few CCITT study group meetings. As a result, the study group consists essentially of delegates from advanced countries. This is a reasonable circumstance in connection with the mainstream of the CCITT work, which is agreement-making for applications of new and recent technology. But for the study of tutorial needs and applications peculiar to developing countries, detailed definition of the problem and its interpretation should be shared by the people experiencing the problem. In practice, experts from advanced countries musr rely on their personal experience and empathy in assimilating the developing countries' viewpoint.

As a result of this lack of participative dialogue, the manuals and handbooks mentioned earlier represent the best judgement available to the group of dedicated volunteers from advanced countries.

Since New Delhi in 1960, one of the CCITT Plenary Assembly's four formal committees has had the responsibility for Technical Assistance and Problems of Developing Countries. At the last Plenary, Geneva, December 1972, this committee heard arguments in favor of disassociating the handbook and manual writing activities from the concept of special needs of developing countries. A number of delegates, representing a cross-section of developing and advanced countries, expressed agreement with this view. The point was made that the work of the GAS groups "is so useful in that it is of interest to all countries and should not be considered merely as an aspect of technical assistance for developing countries only" [15, p. 186].

The committee completed its deliberations by proposing to change the terms of reference to "Committee on Handbooks and CCITT Activities in Connection with Seminars." This proposal was adopted by the Plenary Assembly and incorporated in the Revision of Resolution 1 [15, pp. 202–203]. Implementation of this new look awaits the next Plenary Assembly, scheduled for September, 1976. Full acceptance of the new look would be tantamount to a reconciliation with the missing dialogue. It would make it a reasonable situation that some developing countries are more alert to tutorial requirements, while some advanced countries respond to these requirements by way of interpreting them as their own.

V. TECHNICAL COOPERATION DIRECTED BY THE GENERAL SECRETARIAT

A. Basis for the Activities

Since 1960, the General Secretariat has institutionalized the Technical Cooperation Activity by creating a department for it. The way to get more action in this category of work is to place requests with the Secretary General, who will enlarge the department and its scope accordingly (subject to budgetary constraints imposed by the Administrative Council). The Resolutions in force since the 1973 Plenipotentiary Conference form, in effect, a coherent structure of requests on behalf of developing countries. Resolution 16 addresses the Administrative Council, authorizing continued participation in the UNDP and requesting an expeditious follow-up by the Secretary General. Resolution 17, titled, "Improvement of Union Facilities for Rendering Technical Assistance to Developing Countries," continues authorization of a Group of Engineers in the Technical Cooperation Department. Resolntion 19, "Special Measures for the Least Developed Countries," insrructs the Secretary General to study the state of relecommunication development in these 25 "hard core least developed countries," and to report his findings together with remedial proposals, to the Administrative Council. The Administrative Council, in turn, is instructed ro take appropriate action.

In some 15 years of fast-growing operation, the projects, mounted in and for over 100 developing countries, have covered such a wide range of telecommunication problem areas and a comparably wide range of problem-solving approaches, that any summary type description must by needs be grossly inadequate. The interested reader is urged to consult more detailed and more specific references, in particular the Special Issue on Technical Cooperation of the *Telecommunication Journal* [16]. The activities take the form of seminars, individual country projects, and projects benefiting a group of countries or entire geographical region.

B. Seminars

In general, the ITU Seminars cover a specific subject area and include worldwide participation. Subjects include Administration of a Telecommunication Organization, Application of Satellite Telecommunications, Rural Telecommunications, and specific aspects of the Radio Regulations. Lectures are generally given by volunteers from member countries and some members of the CCITT, CCIR, and IFRB staffs. More recently, the subject of human resources in general, and training of technical personnel in particular, is becoming a favorite. Papers presented at these seminars are sometimes published as bound books, offered for sale by ITU Publications Department.

C. Resident Counselors (Experts)

A few, very senior telecommunications people hold relatively permanent ITU positions in the field, under the title of "Regional Counselor" (formerly "expert"). There are now two such Regional Counselors for Latin America, residing at Lima and Carácas, respectively; three for Africa, residing at Addis Ababa, Dakar, and Libreville; and one for Asia (assisted by two specialized experts), residing at Bangkok. These Regional Counselors have the task of coordinating the ITU technical cooperation activities for the subregion assigned to them. Included in this task is the very important coordination with the UNDP offices, through which the UNDP country programs are supervised and monitored. Each of these six counselors is a native of the respective region and has held high executive office in his native telecommunications administration. Other broad-gauge experts or "project officers" are employed for several years residence at Geneva headquarters, from where they provide consulting services.

D. Single-Project Experts

A common arrangement for expert service is the temporary employment of a qualified person for the needs of one project in one country. Since the program's inception, several hundred experts of many different nationalities, mostly engineers, have served on such assignments. These assignments, usually paid for by UNDP, range from two to five years; sometimes for as short as six months. Several European governments have arranged for an "associate expert" scheme, whereby young engineers may serve under the direction of a senior man. The cost of the associate experts is donated entirely by the donor government organization.

E. Projects of Unusual Scope

Several telecommunications engineering schools and training centers have been planned and put into operation by teams composed of ITU experts and qualified people drawn from the country or region for which the center is to function. Another class of project is the Pre-Investment Survey which bridges the gap between recognized, but often vaguely formulated, general needs for telecommunications and specific plans for specific equipments at specific times to meet specific service objectives. A financing agency may then be assured of a reasonably sound basis for the investment, and procurement of equipment as well as plans for training of people can be definitively specified. Some examples of similar projects are briefly described in the following paragraphs.

F. Centro de Estudios de Telecomunicationes (Carácas, Venezuela)

This telecommunications studies and training center was created by an agreement between the government of Venezuela with UNDP and the ITU, executed in 1964 and renewed for a second phase in 1971. It is intended to fill the needs of CANTV (National Telephone Company of Venezuela) in specialized human resources. This goal is attained through nine different programs. They include:

1) apprenticeship for youug people ages 14–18, as required under Venezuelan law; 2) programs for qualifying workers in outside plant, switching, traffic, and other service qualifications; 3) a step-by-step program for qualifying as technicians; and 4) an upper level program for recent engineering graduates. There is even a "Primary Education" program which enables older workers without education to acquire in 15 concentrated weeks the knowledge equivalent to 6 years of school.

G. The Pan-African Telecommunication Network (PANAFTEL)

The project known as PANAFTEL is one of the most ambitious ever undertaken. When the complexities of the African continent are kept in mind, the successful mounting of such a project borders on the miraculous. Only in recent years have the African countries gained their independence, and the colonial heritage left strong external dependencies. For one thing, African countries are either francophone or anglophone, while a few are educated in Portuguese. The countries are not only separated by a language problem, but are also brought up along the different lines of the French or English way of doing things. The major cities in these countries have telecommunication links with the capital cities of the colonial mother country, but not with each other. The question of a community of interest justifying direct telecommunication links between African cities is difficult to answer. Since there is no history of modern intercommunication made available, how does one know? Against this background, the proposition of a Pan-African Network needed first of all credibility and political support at the highest levels.

It is the proud achievement of the ITU, drawing strength from its four permanent organs, to have helped establish the credibility and feasibility of this undertaking. It began with the first meeting of the Plan Committee for Africa in 1962. By agreement with the Economic Commission for Africa (ECA) and the Organization of African Unity (OAU), the ITU began systematic studies as early as 1963.

After an experimental HF pilot link had demonstrated the limitations of this technique, detailed survey work was carried out under ITU responsibility, beginning in 1968. In all, 38 countries were visited, representing over 80 percent of the African population and land area. The report of this preliminary survey was encouraging enough to persuade the UNDP of the need for a more detailed Pre-Investment Survey. The Pre-Investment Survey was completed in the 1973–1974 time frame. The ITU was subsequently involved in efforts to secure financing for the implementation of PANAFTEL, together with the organizations already mentioned and the African Development Bank. As of late 1975, the project is well advanced into the implementation phase. Costs for the transmission routes have been estimated at $115 000 000. The plan provides for 27 country long-distance systems, totaling about 20 000 route miles in length. The overwhelming majority specify high-capacity microwave, with a few troposcatter or coaxial routes, and one HF radio system.

H. Regional Working Conference "Data Collection on Ground Conductivity and Radioelectric Noise"

A Latin American Region conference (scheduled by the ITU, in collaboration with the authorities of the countries of the region), on the above-named subject was held at Lima, Peru during October 1975. The project, funded by UNDP, has as its objective the coordinated and most efficient utilization of the radio frequency spectrum in the region.

The work of the conference was organized in three committees, dealing with Technical Measuring Standards, Instrumentation, and Programming of Measurements, respectively. The ITU Regional Counselor served as coordinator, and three ITU experts served as advisers to the three committees. Technical people from 22 countries of the region participated.

At this conference, a program of ground conductivity measurements was outlined and specific tasks were determined for each country, using specified instrumentation. In a continuing dependency on the ITU, 12 countries require experts in order to perform the job at all, while 8 are prepared to perform it on their own but need expert help to analyze the results. The conference suggests the establishment of a Regional Center where such tasks can be planned, guided, and coordinated in the future. This proposal, too, is brought to the attention of the ITU for all the assistance it may be able to give.

VI. CONCLUSIONS: THE ITU'S TWO FACES

In this paper, we have directed attention to the ITU's functions as a service organization engaged in technical cooperation. We find that the central purpose of the ITU has not changed much, but that implementation of the purpose has changed drastically. The large membership majority constituted by the developing countries needs one kind of technical cooperation; the industrialized countries among each other need another kind. Yet both kinds of cooperation, the oue that assures technical standardization and worldwide service compatibility, and the other that assures the development of compatible national systems in all countries, may be seen as partners in the same global enterprise. This partnership is demonstrated (but not exhausted) by the production of tutorial technical handbooks and at technical seminars. As in most partnerships, it is natural that each partner chooses the organizational strengths and methods most appropriate to the achievement of his objectives. Thus, we find that the needs of developing countries are expressed and voted at governmental-level conferences, where the majority vote can be most effective. On the other hand, the needs for worldwide technical standardization are decided at the level of technical experts meeting in rather informal study groups, and the results of their work must be unanimously acceptable.

These two kinds of technical cooperation, both vigorous, are giving the ITU two faces. Both faces are valid and legitimate. The face that represents technical cooperation on behalf of developing countries may look very bureaucratic to some observers. The administration of many diverse projects in some 100 different countries certainly requires a substantial bureaucratic apparatus. It is a challenge to the direction of the ITU organizatiou at its top levels to maintain the balance between the two faces, and at the same time operate a strong and effective bureaucracy.

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Planning Communications Systems in Developing Countries

LESTER A. GIMPELSON

Abstract—Technology for planning communications systems has generally been designed for applications in well-developed communication networks. There exists a question on the appropriateness of these techniques and equipment to developing countries with a high growth rate. This paper discusses five aspects of telecommunication planning for the high growth era in developing countries: forecasting, concept of service, planning technology, appropriate equipment, and technological flexibility.

BACKGROUND

TECHNOLOGY for planning communications systems has generally been designed for application in well-developed communications systems; similarly, switching, transmission, and associated equipment have been designed for installation into advanced networks. There exist questions on the appropriateness of these techniques and equipment to developing countries. Telephone networks of developing countries are usually lagging behind those of developed countries in penetration and service, but they are frequently growing at quite high rates, sometimes extraordinary rates. Therefore, the importance of effective planning early in the network's development is very great, as decisions made during an expansion period will affect a country's communications services for many years to come. Yet the phrase, "We can't afford the time and cost for planning," is still heard. However, the proselytizing for long-range planning which has been under way for several years is producing progress as more countries prepare long-range plans with their own technical staffs, or jointly with their suppliers, with ITU assistance, or with consulting firms. Also, modern communications equipment has increased flexibility for successful application in a broad variety of situations.

Communications systems in many developing countries are characterized by high growth rates, and the planning of these systems is the subject of this paper. Long service lives for communications equipment (usually 30–40 years), the difficult requirement that all new equipment be compatible with all existing equipment, the costliness of network rearrangements or modificiations—these considerations point to the need for planning at an early stage in the development of a national network. For the rapidly expanding network, there is a real advantage to early planning, since existing equipment soon becomes a small part of the total installation and decisions can be made assuming either retirement or modification of current systems.

In addition to high growth rates, other characteristics are sometimes observed in developing countries (and less frequently in advanced ones): tight restrictions on capital investment for communications; incomplete statement of countries' communications goals, requirements, and priorities; undefined criteria for service quality; substantial unsatisfied subscriber service requests, which make unexpressed demand difficult to judge; inadequate historical traffic and commercial data; insufficient traffic-measuring equipment; traffic congestion, which may invalidate traffic forecasts based upon measurements; planning departments which must handle immediate problems rather than long-range projects; frequent changes in managers and also in technical staff; and small purchases from many suppliers due to financing difficulties. Rapid communications growth, which may constitute an important percentage of these nations' capital investments, coupled with these factors, leads to a view of planning techniques for developing countries differing from that of more advanced countries.

Early in these discussions it becomes necessary to differentiate between two situations, namely those countries which have begun major expansions which are self-financed through income from oil or mineral exports, and those whose financing is still external, a situation which may lead to reliance on many suppliers. In the first case, administrations usually standardize on a very few major systems, while in the second, availability of external financing changes with time and therefore so do suppliers; this second case requires special planning efforts to prevent interworking problems.

The several characteristics noted above, even though somewhat negative in tone, should not be taken as criticisms, but rather as a statement of conditions caused by current exigencies. The question is an immediate one and positive: given these circumstances, how should planning proceed? This paper outlines planning areas which are particularly important for the high growth era in developing countries, and indicates which techniques are appropriate to the tasks, as well as those which are of little value; it also lists service criteria and national goals which must be fixed prior to initiation of studies.

THE PLANNING TASK

A commitment to planning implies a high-level decision (in many countries at a governmental level) to allocate telephone administration resources, consisting of technical manpower and capital, to the task. Since developing an adequate planning staff requires several years, the planning process can be accelerated by initially using the services of a communications supplier who has the experience, technological tools, and resources to assist an administration in preparing a national plan; alternatively, CCITT offers assistance in the form of assigned experts, but this is usually not as comprehensive as assistance from a supplier; private consulting firms are also available, for assistance only or for production of an entire

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national plan, and recently several technologically advanced administrations have offered similar services for sale.

[Obviously, a consulting firm should be chosen after considerable study, and with the same care as would be taken in the selection of a new switching system. Here care must be exercised to guarantee that the consulting group does not just recommend practices in use by the parent administration; these may not be appropriate in the developing network.]

Continuity is necessary for the planning task. Frequent changes in technical staff and managers hinder orderly development of a national plan as well as its later implementation. These staff changes are frequently accompanied by purchases from many manufacturers due to the external financing problem noted earlier. The result is a fractionalization of market which presents problems to both administrations and suppliers. Administrations must deal with a plethora of equipment types leading to difficulties with inventories, maintenance personnel training, and interworking; suppliers must respond to small orders, and therefore cannot afford the major technical and marketing support which would accompany larger orders. This supplier's difficulty also results from the small total market size in many developing or newly independent countries. To counter these difficulties, there have been several attempts at regional planning, specification, and purchasing. Unfortunately, they have not been very successful in developing areas, although in advanced areas regional agreements have produced real advantages (for example, the Scandinavian countries). Regional planning may consider both the domestic and international networks of the region, or concentrate on the international network and its interface with the rest of the world. Individual administrations' beliefs that their situations are unique, coupled with local politics, have thwarted even international network accords.

[At a recent international telecommunications conference, several technical talks were presented on regional projects. The regions overlapped, but there was no discussion of interfacing between the different projects or even recognition of the overlaps; in one case, the same philanthropic organization was sponsoring two different studies whose regions partially overlapped. Papers read by administrations within a particular region indicated widely different views on the project and even differences in which countries were included in the region.][1]

The planning task needs to cover all aspects of a country's communications needs. Several developing countries in the self-financing category have begun extensive planning and design studies with their suppliers, ITU, and consultants, covering switching, transmission, outside plant, services and features, domestic and international network structures, personnel training, commercial office preparation, and resource allocation between residential and business installations.

[On the other hand, in a few advanced countries, there has been a continuing stream of unnecessary government-sponsored studies of new and sometimes exotic services employing communications facilities. Rather uniformally these trials have shown the public to be uninterested. This form of governmental attempt to foster consumer consumption (albeit of services rather than products), contrasts with the lack of forward planning by several advanced administrations operating in countries whose economies are currently depressed. Major increases in tariffs and reductions in services have resulted in income drops and even underutilization of existing communications facilities, which serves neither the administration nor subscribers. These administrations seem not to recognize that communications quality has a positively correlated effect on a country's overall economic condition, even if that correlation cannot be accurately estimated (see the paper by D. J. Marsh in this issue).]

FORECASTING

Forecasting is always recognized as the first stage of planning, but it must be appropriate to the situation. When there is a lack of historical data and substantial unsatisfied customer demand, accurate forecasting is not possible and this fact should be acknowledged, rather than pursue techniques which add useless precision to inaccurate results. (The computer adage about "garbage in, garbage out" applies equally well to forecasting.) There are decisions with long-term consequences where detailed accuracy is not required, and those areas deserve attention even when accurate data are not available; examples include numbering plan, network strueture (number of hierarchical levels), tariff structure. Alternatively, for shorter term decisions where details are required, inherent inaccuracy should be acknowledged, a forecast made, and planning proceed with flexibility provided to accommodate later forecasts; this view of designing for flexibility means an extra immediate investment to facilitate possible future changes and is akin to purchasing insurance on the forecast's accuracy.

If forecasting is considered as planning's first stage, the "zero-order" stage is data collection: measuring traffic-sensitive quantities, recording service requests, and maintaining accurate equipment inventory and assignment records. In each of these categories, retention of historical records is essential, for only in this way will rational forecasting be possible. The utility of the planning aids to be discussed later is sharply diminished by lack of foreeasts based upon historical data.

[A survey was made of 15 countries and 2 possessions in a restricted geographic area, all of which are considered "developing," with 2 approaehing "developed" category; 6 have their domestic or international services, or both, handled by administrations or concessionary organizations based in Europe. About 50 percent made some traffic measurements, although usually only "total minutes" on outgoing international traffic for revenue-division purposes; less than 25 percent retained some

[1] This example, as well as subsequent ones used to illustrate both problems and solutions, is taken from the author's experiences working with telephone administrations in many countries on several continents. While the examples are accurate in their representation of actual situations, in most cases, details have been omitted to preclude identification of the administrations involved. It is gratifying to note that, in many cases, efforts to correct the diffieulties described are proceeding successfully.

historical traffic data for domestic services; about 70 percent had adequate facilities files. Of those 11 countries with indigenous managements, only 4 collected and maintained sufficient traffic data for useful forecasting.]

Since a major expansion project will materially change the quantity and quality of a nation's services, historical data may not be relevant; instead, new installations should be equipped with traffic-measuring equipment to maintain service levels and begin collection of historical data.

Two kinds of forecasts are required, the traffic forecast and the commercial forecast. For the traffic case, network congestion obscures true load levels, since measurements register total load, made up of new calls and repeated attempts, both successful and not successful. These repeated attempts put increased loads on switching equipment and on long-distance trunks [1]. For commerical forecasts (lines, PBX's, services), substantial unsatisfied demand causes errors, since waiting lists do not accurately mirror demand, as it is always difficult to estimate "unexpressed" demand.

[Several countries have observed that their waiting lists remained constant in length or even grew as their installation rates increased and the delay between service request and installation shortened. One administration reported that installation delays stayed at 18 months over an 8-year period, even though installation rates increased sharply; finally the delay decreased to a target value.]

When there is a large waiting list, and larger unexpressed demands are estimated, a commerical forecast is still required to forecast the date at which installations will be sufficiently up-to-date to meet the service criterion for installation delay. This follows from the fact that network growth will be determined more by capital and equipment availability than by the demand queue (both applied and unexpressed). The forecasting procedure thus moves from estimating demand to assigning national priorities: that is, what part of a national investment budget will be allocated to communications, and from that part what detailed allocations will be made?

The statements immediately above do not hold for traffic forecasts, since they are needed for equipment and trunk dimensioning to maintain quality of service criteria for existing snbscribers. A balance is needed between the number of subscribers and service quality; too often service criteria are not maintained in order to supply service to a maximum number of subscribers; this is an uneconomic solution (see the next section).

When long-range forecasts are required (for numbering plans, network organization, tariff structures, etc.), these can be made by observing the experiences of other countries. [2, figs. 3, 5, and 6] show that historical line-density developments in many countries have quite similar growth patterns, which fit into a narrow band on about an average curve. Graphic and analytic techniques are available to determine where on the general curve a country might be [3], [4].

All of these methods require substantial past history to place an individual country curve on the general one. When data are not available, correlation to the parameter in question is attempted with items like per capita gross national product (GNP), individual income levels, retail sales, etc. [5]-[7]. These correlations have the advantage that in most countries economists put considerably more effort into forecasting GNP than telephone lines and an administration can use these figures. However, while GNP and individual income figures usually correlate well with gross telephone statistics, attempts to use various consumer goods (cars, TV's, refrigerators) are not recommended, since they have not produced consistent results: that is, items with high correlation in one country do not correlate well in others. Further, these gross figures are of limited usefulness for other than line-density predictions; for example, long-distance national and international calling levels mainly respond to quality of service and tariffs. Experiences of developed networks would be useful in predicting traffic stimulation resulting from initiation of customer-dialed long-distance calls and from tariff reductions, but these statistics are considered as confidential and are not generally available. For more detailed forecasts, like traffic loads between particular cities or countries, or line development in a certain city, there exist no substitutes for accurately collected historical data!

[Traffic over the North Atlantic has been measured, studied and forecast more than any other; yet in retrospect these forecasts have regularly been too low. Underestimation is endemic to voice communications for forecasting; this applies to international, national, and local service growth. Alternatively, data traffic forecasts have proven too high.]

CONCEPT OF SERVICE

A concept of service is required before a plan to meet commuuication goals is devised. Service implies more than traditional blocking perceutages: it includes which subscriber services or equipment will be provided (e.g., coin telephones, subscriber long-distance dialing [national, international, or intercontinental], single or multiple party lines, push-button telephones, etc.); how services will be apportioned geographcially (e.g., business versus residence, urban versus rural, rural multiparty or rural manual); response times (e.g., delay for installation of line or extra equipment, restoration of service); and all aspects of reliability.

Using CCITT-recommended criteria for ultimate goals is acceptable, but intermediate goals are required. Although 1-3 percent blockage is suggested for final groups in a national network, this performance may be uneconomic for a developing network. But 20 percent overflow or higher is also uneconomic, dne to inefficieucies caused by reattempts; these inefficiencies affect both transmission facilities and switching equipment. In a congested network, very high occupancies do not connote efficient operation: for example, highly occupied trunk groups are largely occupied with nonrevenne traffic; similarly, common control switching eqnipment is known to operate inefficiently in congested situations where attempt rates exceed machine capacity. The effects of network congestion and control of congestion are a separate topic, too large to treat in this paper, but particularly important to developing networks. (References [1], [8]-[11] treat this topic, namely network management, including service and revenue effects.)

The important service question is associated with resource allocation: should service be provided to as many subscribers as possible, given available capital funds, or shonld service criteria together with capital availability determine network growth?

[Substantial congestion is frequently observed in developing networks. This occurs because local switching machines are overassigned and insufficient intermachine trunks are provided. The motivation is to supply telephone service, albeit of marginal quality, to the largest number of subscribers, in the belief that it will satisfy the greatest number requesting service and also bring in the largest revenue via initial connection deposits and monthly bills. References [1], [8]-[11] show that this philosophy is uneconomic since the network's revenue production is low, inhibiting future growth by reduced income. The result is a longer time to reach satisfactory performance and penetration than if restricted but satisfactory service were provided during the development period.

It has been noted by Ellis [12] for developed countries, but is also relevant to those developing, that employment of telecommunications facilities leads to dependence on them and "excessive" usage, which compounds the problems of a poorly functioning network.]

The preceding remarks summarize the statement that, when capital availability is limited compared to requests for service, a good performance grade should be planned and maintained at the expense of initial growth, as this eventually leads to faster growth and reduced operating costs. In some countries, this is a politically unpopular approach; however, a financially sound telephone operation is advantageous when loans from suppliers, banks, or international funds are required for expansions.

In a similar sense, services provided should be appropriate to a country's requirements, technological capabilities, and resources. A humorous catch phrase has been used, which contains good advice: "Dial tone before Touchtone."[2] Unless other services can be justified by economic usefulness to a country or by revenue production, properly functioning basic services should form the initial fundamental plan, while deferring more sophisticated offerings.

In addition to setting service quality at acceptable levels, early decisions need be made on: 1) priority given to business over residential requests for service; 2) allocations to urban areas versus rural areas; 3) whether residential service will be single or party lines; and 4) when dial service will be introduced in rural areas.

[A multitude of small and slowly growing villages and towns characterize a country which also has several large and rapidly growing cities. Demographic forecasts indicated continued high urban growth, with quite limited rural growth and economic advancement. Further, there were substantial waiting lists for business and residential service in high growth urban areas. Several alternative plans were proposed under the constraints of limited capital and trained technical personnel.

1) Low capital investment manual service could be provided to most rural areas; an underutilized rural labor force would be used to operate this service; forecasts showed 10- and 20-year requirements of usually less than 20 lines per board; this plan provided maximum capital for urban business development.

2) Using the same ratio of rural-to-urban investment as in 1), fewer rural areas could be supplied with dial service via small, unattended rural exchanges; the number of rural exchanges varies inversely with their sophistication.

3) Automatic dial service could be supplied to the same rural areas as in 1), with a reduction iu rate of urban provisioning.

Plan 3 was chosen, because of "embarrassment" which would result from yearly publication of percent-automatic statistics in American Telephone and Telegraph Company's (A.T.&T.) publication, "The World's Telephones," and because of the "need for social training" the rural labor force in operating manual boards, which obligation the telephone administration did not believe it should undertake. While the first reason was stated with some levity, the question remains as to which service goal has higher utility: a high percent of automatic dial lines, or an improved lines-per-person figure.]

PLANNING TECHNOLOGY

Planning technology involves diversion of staff and funds away from immediate requirements, frequently at times when these resources are urgently needed. Good planning will produce savings in future capital and operation expenditures far exceeding current costs. "We can't afford to allocate staff and funds for long-range planning," is not a valid statement!

Planning staff's capability and capacity will be extended through use of computer aids which provide the most modern planning tools, from simple dimensioning to complex decisions on national network structures. These aids are available and need not be developed or modified for a particular country. The desire to reinvent algorithms, techniques, and computer program aids is quite strong in planning groups, motivated by intellectual fervor and by the mistaken belief that local problems are unique, requiring unique techniques that result in unique solutions. Indeed, experience shows that unique techniques and solutions are rarely warranted.

[Substantial experience has been obtained using a computer program to assist in determining economic locations for new exchanges. See [13], [14] for a specific example: this program has been used in excess of 500 times, for 175 cities in 12 countries. Many cities having purportedly unique problems have been analyzed using this computer aid without its modification, even though opinions prior to its use frequently questioned its applicability to the specific network.]

Computer programs designed for planning aids are produced by teams specializing in these techniques and are quite expensive to develop (design, program and code, field trial, document). An administration's planning staff would dilute its effectiveness by adding computer-program development to its planning tasks.

It should be clear that a program's output is as accurate as the input data, and earlier remarks about forecasting and data

[2] "Touchtone" is push-button dialing.

collection and retention are relevant here. Programs do provide a convenient facility for testing the sensitivity of plans to differing forecasts and are particularly useful in finding solutions which tend to be insensitive to inaccuracies of forecasts.

Programs for planning tasks have been reported extensively in the literature. It is appropriate here only to emphasize the great value of these aids to a developing nation's planning staff. References [13]-[25] are to computer-assisted planning techniques; this is not an exhaustive list.

Planning staffs should avoid wasted efforts on techniques which are inappropriate in the sense of not contributing to the planning process. For example, when traffic forecasts are made with limited historical data, corrections for nonrandom overflows are not worth the effort entailed, since they are small compared with the uncertainty of the forecast traffic loads; time would be better spent in improving forecasts or designing network configurations less sensitive to forecasts' inaccuracies.

Noting earlier remarks that unique techniques and solutions are rarely justified, this fact can be extended: planning should lead to standard planning techniques and also standard communications equipment, the latter yielding to economies, shorter delivery schedules, and also fewer equipment problems from new designs.

> [The fallacy of unique requirements is frequently the result of poor planning. Upon receiving specifications for a unique signaling system to be used for a developing country's national network, the supplier attempted to convince the administration to accept "off-the-shelf" equipment, since a unique design would cost about twice the standard, due to special engineering and small manufacturing run. The customer replied that plans for its future network required these signaling facilities. The system has been installed for four years; at present none of the special features has been utilized.]

One fundamental difference exists between planning techniques for advanced and for developing countries: while (broadly) an advanced administration seeks to minimize its expenditures under a service constraint, a developing country having a strong capital constraint should maximize utility. "Utility" here is quite difficult to decide, as the earlier example of rural-versus-urban allocation demonstrated. The planning staff needs to differentiate between these two criteria; planning techniques and computer program aids are readily adjusted for the second criterion. But the efforts to define utility, the goals by which progress will be judged, and the concept of service in all its aspects are too frequently neglected even though the specification of these items must precede the application of planning techniques. Further, utility has two aspects, one as viewed by the public and the other by the administration [12].

APPROPRIATE COMMUNICATIONS EQUIPMENT

As used here, "appropriate" applies to services noted earlier, to technological level of engineering and maintenance staffs, to availability of capital for equipment investment, to equipment's revenue production capabilities, and to long-range goals and priorities. Is the most modern or most sophisticated equipment appropriate for a developing country? Can the maintenance staff properly handle new equipment; is retraining worth the expense?

In this area, questions of modernity, national prestige, politics, public relations requirements, etc., clash with sound engineering and financial judgement. Many of the issues discussed in the section "Concept of Service" are closely related to choosing suitable equipment: for example, urban lines with high per-line revenue and low per-line investment versus rural lines with low per-line revenue and high cost.

> [A geographically large country has most of its population in less than one quarter of its area. A decision to bring telephone service to the vast low-population agricultural areas was accompanied by the question of appropriate switching system. A recommendation to install step-by-step equipment in low-density areas for its economy, low maintenance, and small technical demands upon the maintenance staff rather than crossbar was not accepted; it was considered demeaning.]

> [Semielectronic (that is, computer-controlled) switching systems have been added to the choice of switching equipment for some years. As a new technology their introduction into a country, especially a developing one, can put a strain upon technological capacities, particularly retraining requirements. As with any new system, problems and advantages of semielectronic should be weighed in view of the milieu into which the units are put. Justification far beyond prestige is a requirement for introducing any new system. And now PCM exchanges are being considered, in several cases without regard to their current high cost, especially for local application. One small administration has announced that since crossbar exchanges will satisfy its end-exchange needs for many years, it prefers to avoid two changes of technology and will continue crossbar additions until PCM exchanges are cost competitive. Another administration will introduce PCM immediately, largely since it has been offered financing for the equipment.]

> [Prestige may have motivated some installations of another technologically new system, namely, satellite earth stations. In one area of about 16.7 million people, comprising mainly small, developing countries, there are currently five earth stations, and two more are being constructed. Even considering the political problems associated with regional communications agreements, this is an economically questionable arrangement. At the same time, Denmark, Norway, and Sweden, with a combined population of 15.5 million people, use a single station located in Sweden.]

Equipment choice should be subjected to 20-year or longer present worth of annual charges studies, including not only equipment costs, but parts inventories, training and retraining costs, costs for mainteuance of different systems, interworking arrangements, etc.

TECHNICAL FLEXIBILITY

Planning for technological flexibility is a goal for both developing and advanced nations. This means providing flexibility in the communications network to accommodate major technological developments which will result in new services or new equipment.

It is now clear that signaling systems must provide service marks to prevent double satellite hops; but when current systems were developed this requirement could not be forecast. Similarly, semielectronic switching will lead to fully electronic and digital networks: how should current network design be affected by this development? In many countries, step-by-step equipment has been modified to permit customer-dialed long-distance, international and intercontinental calling; in other countries, modifications are considered too costly and these facilities will only be provided on new exchanges. While manufacturers will attempt to supply conversion equipment, the currently accelerating trends may make these conversions increasingly uneconomic. So there is a possible contradiction here: while semielectronic and fully electronic exchanges may be correctly unsuited for some developing countries because of problems resulting from the sharp changes in technology, their flexibility for accommodating future services is substantial. Techniques are needed to weigh these aspects quantitatively.

Certainly those countries which have embarked upon expansion programs which will rapidly reduce their existing facilities to a minor percentage of the total network investment are justified in introducing semielectronic exchanges. Slower growth cases require careful economic studies. And for all developing countries, the aura of fully electronic systems PCM should be tested against economic realities. At present, there is no answer to the general question of which network and equipment characteristics tend to accommodate technological advances particularly well. It is certain that the rapid pace of technology will no longer permit economical retirement of communications equipment prior to major environmental changes; instead equipment must accommodate the new technology. Technological forecasting and techniques to assure technological flexibility are now the areas most requiring substantial new research.

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Telecommunications as a Factor in the Economic *Development of a Country*

DONALD J. MARSH, MEMBER, IEEE

Abstract—Many different techniques have been studied in the past for correlating the growth of a telecommunications network with the economic growth of a country in an attempt to allocate capital resources optimally. With suitable modifications, several of these techniques have been found to have some broad application, but no universally applicable technique has yet been developed. Of the methods developed to date, however, several of the more intensive ones can usefully be applied to developing countries where the present telephone density is very low in comparison with the industrialized countries. This paper presents the results of using a macroanalytic technique in correlating these factors for several selected countries in Latin America. The results are then discussed in the context of basic telephone demand parameters and the current dynamic technological and economic environment.

GENERAL

THE QUESTION is frequently asked in the telecommunications industry, what relationship should exist between the economic development of a country and its telecommunications networks? This correlation has been frequently studied over the past ten years or so, and several different methods for making such calculations have gained wide acceptance, although a general method for determining optimum levels of investment is still being sought. This paper reviews the most significant of these techniques, compares some of their advantages and disadvantages, and attempts to relate such correlations to reqnirements in some selected countries in Latin America.

Before beginning this review, however, it is important to note some qualifications in correlating telecommunications and economic development. First, a cause-and-effect relation often cannot be clearly established, even when a very high correlation exists between telecommunications and economic development. When considering basic telephone service, for example, it is a well-known fact that telephone demand is a function of at least four different variables, i.e., population, income, price, and infrastructure of the country and its economy. These factors are highly interdependent, and it is well known that improved communications is a stimulus to business and industry, thereby increasing income, which in turn increases the demand for telephones still further. Thus, to define a clear cause-and-effect relationship is not possible, except in only very simple circumstances.

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Second, the infrastructure of a country is a very complicated process of social and business interaction which is highly dynamic. Many changes are occurring at an ever-increasing pace. One of the principal changes happening in many areas of the world, and particularly in Latin America, is urbanization [1], [2]. Population growth and rural-to-urban migration is causing an almost explosive expansion in the major cities. This growth is causing many problems, e.g., food, housing, employment, etc., and one of the secondary effects is to cause significant alterations in the basic telephone demand factors outlined above. Thus, the previous correlations made only a few years ago are becoming less and less reliable as indicators for forecasting telephone demand.

With the world energy situation changing so dramatically in recent years, there has begun an industry-wide search for viable telecommunications alternatives to travel. Many telecommunication administrations are looking intensively at new tariffs and new services such as facsimile, data communications, cable TV, etc., to offer their customers. Thus, the factors of new prices and services will also alter the demand function still more in the next five years.

Therefore, it is evident that many changes are happening which will likely cause significant modifications in the basic relationships between telecommunications and economic development. While this paper will not attempt to define these modifications in detail, a review of the fundamentals in relating telecommunications development to economic development will illustrate some of the most probable changes and what further studies may be required to develop conclusive recommendations.

Finally, telecommunications in many industrialized nations has developed over the years, often as an integral part of the local economy without any unified government effort to relate the two directly. In many of these situations, the local economy was not rigidly controlled, or planned, but grew out of the natural exploitation of total national resources. Varying degrees of telecommunications network development came about in these instances with both good and bad results. As more intensive investigations began in order to establish a more definitive relationship between economic development and telecommunications, it became clear that in developing countries this relationship is highly desirable in order to allocate scarce resources in a more optimal fashion. Consequently, a higher level of research effort is found in these countries. Planned economies in developing countires, therefore, offer the opportunity to employ modern analytical techniques to arrive at more appropriate levels of capital investment in telecommunications, thereby eliminating many of the historical errors which others have encountered.

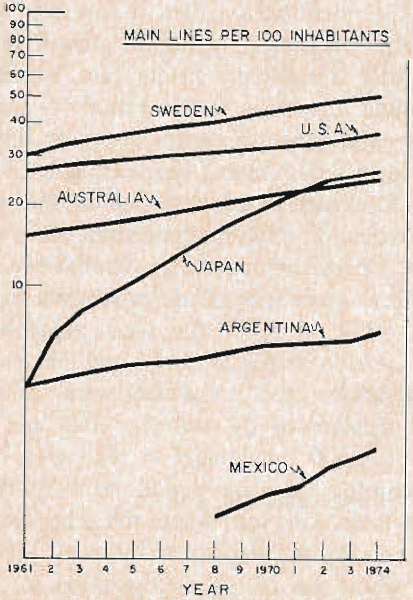

Fig. 1. Telephone density–selected countries.

BASIC ANALYSIS OF DEMAND FOR TELEPHONES

Historical development of telephone growth is most often shown as a percent of population, and is sometimes used independently to project the future telephone demand. Since the growth is not generally linear, these projections are commonly shown on semilogarithmic scales. Some typical examples of different growth rates are shown in Fig. 1. Basically, such charts are used as a very simple forecasting device since trends are more easily perceived in this manner.

With more countries going towards planned economies, a more technical and accurate forecasting tool has been developed which relates the gross domestic product (GDP) of a country to telephone density. Although this is considered a macroeconomic parameter, GDP generally reflects the economic growth of a country. If this factor can be predicted in advance with a reasonable degree of confidence, then relating historical telephone growth to GDP would allow projections of future demand to be made. The problem, of course, is to accurately correlate GDP to telephone density over an adequate amount of time to result in a meaningful equation. As with several other methods of forecasting, this technique depends on the continued stability of historical trends, and the time periods must be carefully chosen to reflect a distinct, and real, trend.

Similar to the relation between telephone growth and population, the telephone density versus GDP is often linear in logarithmic terms, and is conventionally shown as GDP per capita compared with telephone density. An internationally recognized procedure for calculating this relationship is presented in the CCITT Recommendations "Economic Studies at the National Level in the Field of Telecommunications" (The International Telegraph and Telephone Consultative Committee). This procedure basically plots the growth data for the factors involved, and then a determination is made to see if a correlation exists by linear regression [3].

The average GDP growth for Latin America from 1961 to 1970 was approximately 5.5 percent. This average was not

	1961-1970	1972	GDP Per Capita Base
Argentina	4.2	3.7	$1,095 U. S.
Brazil	6.0	10.4	464
Chile	4.4	1.6	945
Colombia	5.2	7.1	376
Costa Rica	5.9	6.4	572
Ecuador	4.9	9.9	308
Mexico	7.0	7.5	709
Peru	5.3	5.8	503
Venezuela	5.7	5.5	1,115
Latin America	5.5	6.9	591

Fig. 2. Overall gross domestic product growth (percent) and per capita base.

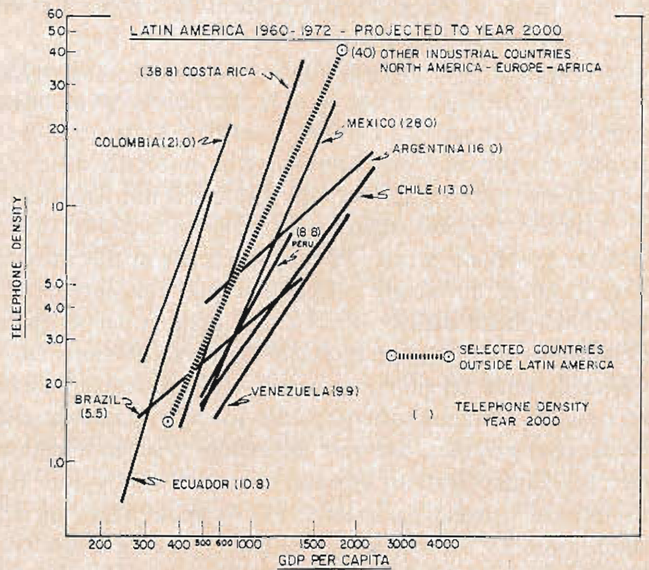

Fig. 3. Telephone density versus GDP per capita, Latin America.

uniform over the entire period, and shows an increasing trend in the latter years. There appear to be well-organized plans to continue this growth, and figures for 1972 and 1973 indicate that a 6.9 and 6.8 percent respective increase has been maintained [1]. The real growth, however, after accounting for population growth, was about 2.8 percent annually [4]. Fig. 2 shows the overall growth in GDP for nine selected countries to illustrate this strong upward trend.

Using the method recommended by the CCITT, the correlations of telephone growth and GDP were calculated for the selected countries for the same period and are shown in Fig. 3. All of these correlations show very similar growth patterns, and indicate surprising correspondence with a general regression line for the period 1960–1965 for 40 major countries outside Latin America. However, the overall telephone density in Latin America for the later period (1971–1974) is somewhat over 4 telephones per 100 population, and far lower than North America (64 percent) or Europe (18 percent) [5].

Thus, with the exceptions of Argentina and Brazil, the other seven countries have demonstrated that their telecommunications growth has been comparable to other countries of the world when related to economic growth, but that if allowed to continue along this trend, it would not produce comparable telephone densities in the next 25 years to what is already an accomplished fact in many other industrialized areas. It is obvious that a higher national priority must be placed on telecommunications in these developing countries.

FUNCTIONAL ANALYSIS OF THE DETERMINANTS OF DEMAND

As mentioned earlier, telephone demand is dependent on a minimum of four different variables: population, income, price, and national infrastructure. These variables are not independent, however, and in most cases the relationship between them cannot be definitively stated. Nevertheless, taken as an aggregate and with appropriate qualifieations, they form the basis for predicting telephone demand [6]. Before considering the first three of these factors individually, some further provisos need to be presented.

First, aggregate, or macroanalysis, such as that presented in the preceding section, is not terribly useful, except to make rather broad comparisons between countries. And even in that instance, the mix of basic factors may be so totally different that such comparisons are not fair. Thus, it is not feasible for any national policies regarding telecommunications to be based on telephone density calculations made in this manner alone. It must be clearly understood that the appropriate level of telephone density is not a high number per se, *but a sufficient density to support economic and social development.*

Second, while telephone service is the predominant social and business communications media for both domestic and international purposes, the rapid technological advancement of other telecommunications systems may significantly alter the conventional demand parameters. For example, there are 8.5 million cable TV subscribers in the U. S., growing at the rate of 12 percent per year. These subscribers are served by approximately 3000 cable systems which could connect as many as 20 million residences, representing almost one-third of the homes with TV in the United States [7]. There is considerable activity and developmeut in the U. S. to provide interactive residential services on this network which, in essence, would supply a videophone connection much the same as the Bell System's Picturephone® to subscribers. While the United States' political and economic organizations are not entirely ready to accept such a development, it is not hard to visualize that a constant 12 percent growth rate for cable TV versus the current 6 percent growrh rate for telephones in the U. S. could mean an equal number of cable TV and telephone subscribers within the next 50 years. The demand for both of these communication services will change appreciably before then as they influence one another mutually.

Population as a Factor

Population growth in Latin America is higher than elsewhere, and there is much evidence that urban development requires considerably higher priority in many countries because of this high growth and its impact on economic development. Several facts, however, concerning population which influence telecommunications should be noted. Economic development, as mentioned earlier, is now over 6 percent and although Latin American population growth is higher than elsewhere, there is a net per capita gain, which means that high population growth is not necessarily restrictive as long as economic development is greater. However, this rapid population growth is also changing character quite rapidly, and if it continues to change in the same manner, then current views on the provision of relecommunications services should be reconsidered. Overall population growth has been increasingly concentrated in urban areas. The comparative growth is startling. From 1960 to 1970 the total population in Latin America rose from 198.9 to 261.7 million, an increase of 31.5 percent while urban population went from 102 to 160 million, an increase of *57 percent.* Rual and small town populations (20 000 inhabitants or less) grew by *less than 20 percent* during the same period. In 1973 there were 10 countries in Latin American where the urban population was close to, or above, 60 percent of the total population. The region as a whole has an urban population of 58.3 percent, and if this growth continues, it is forecast that by 1980 over 65 percent of the toral Latin American population will be residing in urban areas [1], [2].

An independent study done at ITT [4] indicates that because of this urbanization trend, only 4 percent of the total requirements for telephones will be needed in the rural areas over the next 25 years. Despite the recent active considerations of rural area telecommunications systems by organizations such as CCITT and CITEL (Inter-American Telecommunications Commission) and the fact that many manufacturers are currently promoting rural area telecommunication systems, the preponderance of telecommunication requirements will most certainly remain in the urban areas.

One last point should be made with respect to population growth and its influence on telecommunications and economic development. It is commonly known that high rates of personal interaction, both social and business, creates new patterns in social, economic, and political behavior, and this in turn can lead to further development of new economic systems, e.g., businesses, industry, etc. However, such developments will only take place if there are means of communications [2]. This simply means that with the increasing urbanization in Latin America, there is a high probability of stimulating economic development, *but only if the telecommunications network has grown adequately to support such development.* It should be remembered here that adequate telecommunications facilities means not only sufficient quantities of telephones, but also enough equipment to handle higher traffic volumes as well. In summary, however, the mutual effects of telecommunications and social development are not well known and, as it has been suggested before, more study must be devoted to this important relationship.

Income as a Factor

Telephone demand is highly dependent on personal income. A considerable number of studies have shown a strong correlation between these two factors [6], [8]-[10]. The demand for residential telephones, for instance, is principally a function of family income, although there are additional social and

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	Agriculture	Mining	Construction	Manufacturing	Transpt. & Comm.	Power	Trade	Finance	Service	Government	
Agriculture	A11	A12	A13	...	...	...	A1n				
Mining	A21	A22	...	...	A2n						
Construction	A31	:	:								
Manufacturing	:	:	:								
Transport & Communications	:										
Power	:										
Trade	An1										
Finance											
Services											

(a)

Sector	Coefficient(x10-3)
Agriculture	2.3
Mining	1.0
Construction	3.4
Manufacturing	4.0
Transpt. & Comm.	10.4
Power	2.7
Trade	10.5
Finance	8.7
Services	14.7
Government	3.1

(b)

Fig. 4. Industry-to-industry flow of goods and services. (a) Sectoral flow matrix. (b) Sector inputs from telecommunications.

personal reasons for higher residential demand in some areas over others. Business and industrial telephone demand is also a function of income.

In 1970, B. Wellenius at the University of Chile showed a close correlation between short-term telephone demand and a lognormal distribution of family incomes in greater Santiago [10]. Wellenius indicated that family income was the most influential factor affecting residential demand. Additionally, while it is obvious that significant variations in income distribution would cause similar variations in demand, Wellenius also found that this increase in demand would take place when a redistribution of incomes occurred to level out variations, *even though the mean value of the income distribution did not increase.* This study is a most extensive analysis of family income correlations with telephone demand, and it is an excellent example of the level of detail which can be employed in order to establish such relationships for telecommunications and economic developments. Analogous studies have also been made encompassing the more descriptive logistic function or familiar S curve [11].

Similar analyses can be performed in relating the various sectoral business incomes to telephone revenues, and then calculating telecommunication investment requirements based on forecasts of industrial production and the flow of money between each business sector. The most extensive work of this kind was published several years ago when economists began intensive use of input-output analysis [12]. Although this technique is still considered a macromethod, it differs from the gross GDP-demand model discussed previously in that it relates telecommunication revenues individually to as many sectors of the economy as required. Basically, the technique relates the revenue derived from the provision of telecommunication services to each individual economic sector proportionate to the level of business activity between the sectors. Fig. 4(a) and (b) illustrate a typical sectoral breakdown showing the matrix form and a set of inputs to each sector for telecommunications. These coefficients are actual (U.S. Department of Commerce) and typify the variation of telecommunications input to each of these sectors. By factoring each of these input coefficients with the monetary volume of production between each sector, and then summing up all of the products, the total requirements for telecommunication services can be obtained. By using industrial output forecasts, similar correlations between telephone demand and each sector income can then be made. By appropriate choice of the revenue factor, this technique can be used for other communication services as well, e.g., telex, facsimile, telegraph, etc.

Extensions of studies like this have been done in further attempts to establish optimum ratios for telecommunications plant investment to revenue [8]. In the U.S. this optimum ratio had previously been determined to be 3:1, reflecting the fact that telecommunications is a very capital intensive type of industry as opposed to other commercial ventures where this ratio is frequently less than 1. Previous research has shown that when this ratio goes much higher than 3 (>4), then the return on the capital investment is too low, and it would be insufficient to be attractive to potential investors in a capitalist economy. In this case, there is simply too much plant investment for the amount of revenue derived from the system. The opposite is more likely to be the case in a developing country where ratios as low as 2:1 are often found for investment to revenue comparisons. While it may seem more efficient to generate the same amount of revenue for less capital dollars, invariably such networks have an insufficiency of telecommunications plant which is manifested by poor quality service in one or more ways. This ratio, however, is an important parameter and should be the subject of more detailed analysis in developing countries for international comparisons since only a good quality network will serve to stimulate a growing economy.

Price and Other Factors

The cost of telecommunication services to the subscriber is an extremely important determinant of demand. However, when considering telecommunications and its relation to economic development, it must be recognized that such an analytical approach is not an entirely adequate one, and therefore before discussing prices, or rates and tariffs as they are called, the historical role of government-owned administrations must be considered as an important price-determining factor.

In many cases, government policy in the past has impeded growth in telecommunications by keeping prices for services at artificially low levels. This deliberate restriction made it impossible for the administrations to generate enough profit to finance expansion or to attract private investment. In countries where the economy permitted the establishment of many competing telecommunication organizations, the development of small and inefficient telephone networks developed. The countries which have fared the best, i.e., those where the telecommunications growth was highest in real terms, are the ones where a monopoly was granted with just enough government control to assure that only reasonable rates of return were attained. This policy permitted prices to be established in the range where income was adequate to create demand, yet the administration could still generate snfficient internal capital and obtain external capital for developmeut purposes.

However, it is perfectly clear that the role of government stated so briefly is a gross simplification of the entire issue. Events in the U.S. since 1971 have made auy conclusions concerning government regulation of telecommunications tenuous at best. Controversy over many new public issues regarding government regulation, pricing of telecommunication services, competition, supplier-administration relationships, and utilization of new technologies, e.g., satellite communication systems, data processing, etc., have made the situation in the U.S. very indeterminate of this time. No particular trend can be observed in this exceptionally fluid situation, and it would be unwise to attempt to relate the past historical role of the U.S. government to the future or to events in any other country. Nevertheless, it is obvions that government policy is the major factor in the development of the telecommunications industry in any country, and it is within the policy guidelines and restraints set forth by decree that such analytical examination of prices, and all of the market factors relating to telecommunications, for that matter, must be taken. Pricing of telecommunication services has a wide range of impact on demand. In certain situations, prices are a key determinanr, while in others, relative prices of basic telephone service, such as in the U.S., for instauce, have been found to be statistically less important than the availability of the service, thereby suggesting some inelasticity in price-demand relationships. There is no single ideal price structure. There are too many variations between countries, within an economy, and among subscribers to develop what might be considered an ideal set of prices or rates. One of the basic functions of prices for any commodity is to cover total costs and return some margin of profit for expansion where the administration is organized to operate in this manner. This is often more fundamentally termed the function used to allocate the factor of production. Therefore, any pricing philosophy should be aimed to accomplish this purpose.

Other Factors

There are other factors affecting the demand for telecommunication services which are known to influence, or be influenced by, economic and social development within a conntry. Many attempts have been and are currently being made to quantify these relationships, but, in general, they can only be discussed in qualitative terms. Fig. 5(a) and (b) show some of the most significant of these, and emphasize some of the more advanced applications of telecommunications technology to illustrate the degree of added complexity involved when attempting to establish an understandable qnantitative relation between telecommunications and national developments in more than one area. If we take transportation as an example, ler us examine what some of the variables are when considering telecommunication applications (Fig. 6).

First, there is the concept of substituting communications for travel, which is not new. While no one has attempted an exhaustive analysis, it is obvious that some of the first uses of the telephone and telegraph displaced the need for physical travel. Not all travel can be substituted, of course, bnt a considerable amount of business travel could be eliminated by appropriate application of telecounnunications technology. Telecommunications industry people are studying the possibilities of new services such as video-conferencing, home and office interactive data terminals, etc. Such applications would not only create demand for such services as a substitute for travel, but they would also reduce costs and time.

The magnitude of the effects on economic and social development may be appreciated by describing a recent study done for the U.S. Department of Commerce in 1973 [13] where the capital costs involved in land transportation were compared for a city in which 50 000 new business office jobs were to be created. These new jobs could be created over 4 or 5 years, or 10 or 20, depending on the growth rate in that particular urban area. The study compared the cost of building new office space in the accepted downtown business district, thereby requiring new office construction, a new high-speed freeway to carry the automobiles, and a rapid-rail system to carry the workers. One alternative was to create four suburban satellite centers dispersed throughout the residential areas surrounding the city which still required the freeway, a modified rapid-rail system, and some office construction, but less than the first method. The other alternative was to lease space without construction in many different buildings with the objective to locate the office as near to the workers home or neighborhood as possible. This required no new road or building construction, hut required two-way interacrive cable television and other new telecommunication services to basically achieve the same level of personal interaction.

The first method, that of providing the 50 000 jobs in a central business district, would cost approximately $500 million. The second, where four satellite centers were built, would cost $140 million, and the last method, where telecommunications would essentially be the substitute for travel, required no new construction except for the telecommunications system which *cost less than $100 million.*

While it is still too early to forecast what future impacts this concept will have ou urban development, it is quite clear that telecommunications will be even more influential on

(a) ECONOMIC

Finance	(1) Computer communication networks for data transfer, (2) facsimile check verification for banks, (3) video-conferencing.
Business I	(1) Communications word-processing (2) facsimile substitutes for mail (3) cable TV for home shopping.
Manufacturing	Computer communications for process control and factory automation.
Power	Data communications for load balancing, computer control etc.
Transportation	Telecommunication applications for controlling traffic and as a substitute for travel.

(b) SOCIAL

Education	Instructional applications for television
Health	Medical services using video and other telecommunications facilities e.g. data links
Pollution Control	Telecommunications to monitor and send alarms
Crime Prevention	(1) Television surveillance, (2) mobile radio, (3) computer communications for identification

Fig. 5. Qualitative telecommunication factors in development.

TRAVEL VARIABLES

- Location of trip origin } Distance
- Location of destination } Distance
- Route selected } Distance
- Model (car, bus, train) selected
- Time & Cost
- Frequency of trip

CONVENTIONAL ALTERNATIVES

- Telephone
- Telegraph
- Telex
- Facsimile
- Mobile Radio
- Television (Video-Conference)

CONTROL ELEMENTS

- Trains and Track
- Airplane and Guidance System
- Cars, Buses, and roads
- Ships

NEW TECHNOLOGY APPLICATIONS

- Computer control of vehicle
- Conventional traffic control
- Satellite communications for ships
- Vehicle identification & location

SUBSTITUTION BENEFITS

- Reduce congestion in central business districts
- Reduce time in travelling to jobs, business, etc.
- Reduce travel costs
- Increase worker productivity
- Increase efficiency of transportation system

Fig. 6. Telecommunications in relation to transportation.

economic and social development than it has in the past because of such considerations.

NEW APPROACHES

The previous sections of this paper have mostly addressed the more common quantitative aspects of relating telecommunications to economic developments, and it has been shown that although there are many different techniques linking these two important characteristics, there is as yet no completely definitive method of determining the quantity of telecommunications required to support a given economic development for a community of human beings as large as a nation-state and over a fairly long period of time. It is perhaps because there is no comprehensive way to describe such economic development on so large a scale in time and space that a distinct method cannot be found to show how telecommunications can support it.

However, a considerable amount of work is presently going on in several different fields in an attempt to produce more useful methods. Telecommunications people are continuing to study this aspect in greater depth, and researchers in the social sciences and in the field of economics are also conducting independent studies in this area. There is far too much material in these studies to cover in this paper, but a brief description of some recent work going on at Bell Laboratories may be illustrative of the different approaches.

J. Rohlfs at Bell Labs has extended the previous work of two economists, Artle and Averous, in studying the static and dynamic aspects of telephone users as a "system." In a recent paper [14], Rohlfs employs the classical utility concept which states that "a subscriber derives added benefits from a communications service as others joiu the system," and he develops some useful conclusions involving the communities of interest of subscribers and the pricing of telecommuuications services.

The conventional utility function approach is a traditional mathematical method used in economic studies, but has been applied only in recent years to telecommuuications to show that interdependent communication needs among people already subscribing to telephone service, regardless of reasonable changes in income and price, are sufficient to sustain continued growth in the basic demand. This concept has an initial proposition that the iucremental utility of a communications service depends only on the quantity of subscribers. No discrimination in the type of subscriber is made, i.e., residential, business, etc. However, this is an artificial assumption, and while it facilitates the mathematical solution to the economist's problem, it overlooks the fact that telephone users actually form strong community of interest sets. For example, while new subscribers may be added to a telephone system in a remote city, users' calling habits will not realistically change at all as such new subscribers are added. They will continue to place most of their telephone calls to the same telephone numbers as before, and although the value of the telephone system has increased because of the addition of new telephones, the users do not take advantage of this fact.

Rohlfs' study contains an analysis of nonuniform calling, making the adjustments suggested above for separate sets of users, and points to a possible area of future research. The study also relates the quantity of subscribers to the price of the service, suggesting that further analysis could lead to optimal pricing techniques. By extending this analysis, it may be possible to determine how an investment in telecommunications can optimize economic development *providing that some criteria for economic development optimization* exist. The problem would most likely be unworkable any other way. This kind of analysis using Rohlfs' approach could probably be applied to any new telecommunications service and any set or subset of users. Such a new approach may provide a positive and comprehensive technique for predicting telecommunications demand in the near future, and provided that we also have definitive correlations between demand and economic development, we will perhaps reach a conclusive method with which to relate telecommunications and economic development.

SUMMARY

The scope of this paper has been very broad in a deliberate attempt to illustrate the many factors affecting the relationship under consideration, and to further relate these factors to conditions in the developing countries of Latin America. It has been shown that while certain countries in Latin America have experienced telecommunications growth comparable to the norms established in the highly industrialized nations with respect to economic growth, a much higher level of investment is required in order to achieve a comparable telephone density in the future. This should be a high priority consideration [15].

Further, the general state of present analytical techniques has been covered here qualitatively, together with some examples for selected Latin American countries demonstrating the limitations of these methods. While new analytical work is currently going on which promises to bring into sharper focus the problem of relating telecommunications and economic development, such methods will have to be powerful enough to include the dynamic present world situation.

Latin America has more than doubled its gross domestic product in the past 15 years [16], which is the result of a concentrated effort to diversify and expand their industrial base. This is an exemplary record for developing countries, and with the increasing trend in recent years to GDP figures of over 6 percent, the results have been far higher than in other developing areas of the world, and even higher in many instances than in the more industralized countries. However, in 1974 and 1975, this growth was slowed because of changing world economic conditions. It is therefore difficult to suggest that telecommunications investment should occupy a higher priority than other national objectives in developing countries when food and housing are more basic needs, but the fact remains that no matter how imprecise our present techniques are for relating telecommunications to economic development, the overall telephone density in Latin America is extremely low and needs more extensive investment if these economies are to continue to grow at reasonable levels.

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Donald J. Marsh (A'58–M'69) was born in Jamaica, NY, on October 26, 1930. He received the B.E.E. degree from New York University College of Engineering, New York, NY, in 1964, and did postgraduate work in communications engineering at George Washington University, Washington, DC, in 1965 and 1966.

From 1950 to 1962 he worked for the New York Telephone Company, a principal Bell System affiliate, where he held various positions in plant, engineering, and operating staff assignments. In 1963 he joined ITT and was assigned to a subsidiary, Communication Systems, Inc., as a Project Engineer. He performed network engineering for the original AUTOVON system where some of the first applications of computer simulation were done to optimize this military network design. In 1966 he was named Technical Director of the largest ITT-owned telephone company where a special network service improvement program was initiated. Following this assignment, he was made Technical Director of a new ITT research facility in Spain. Here he directed ITT's development of computer programs for network optimization and several other projects, notably the early prototype developments of semielectronic switching. Then, in 1969, he was appointed to the ITT Corporate Technical Staff, Stamford, CT, as Technical Director, Telecommunications Planning, which is the position he holds at present. In this position, he directs a number of systems planning and engineering groups primarily responsible for assisting many ITT customer administrations and ITT telecommunications manufacturing and operating units in developing long-range fundamental plans for network expansion and implementation of advanced products and systems. This work makes extensive use of computer programs applied to network design, system engineering, system planning, and analysis of technical and economic factors pertaining to the development of telephone and data networks in various countries worldwide.

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Some Recurrent Problems of Telecommunications in Developing Countries

BJÖRN WELLENIUS

Abstract—The expansion and improvement of telecommunication services in developing countries is faced with a number of problems of implementation and of method. The problems of implementation have well-established solutions and, therefore, are only briefly discussed in this paper. The main focus of this paper is concentrated on four classes of problems related to method, namely: 1) demand forecasting and its impact on system performance; 2) economic evaluation with special regard to social factors; 3) pricing; and 4) technological dependence on foreign countries. The problems need considerably more research and field work before results of any permanence and general validity are obtained. The paper concludes that dealing with these and related problems of method needs an essentially interdisciplinary approach. It further suggests that only some international technical and development organizations may, in the foreseeable future, be in the position to undertake interdisciplinary sectoral telecommunication studies of adequate breadth and depth to yield meaningful tools for better utilization of the scarce telecommunication resources in developing countries.

I. INTRODUCTION

DEVELOPING countries are often faced with problems concerning the improvement and expansion of telecommunication services that do not arise, have long been overcome, or may be handled in other ways by industrialized nations. Most of these are *problems of implementation,* which have well-established solutions. The difficulty in solving a problem of implementation lies mainly in getting all relevant parties to recognize the problem, adopt a solution, and apply themselves as long and intensely as needed to carry it out. Some examples of problems of implementation at the level of specific institutions (e.g., a telephone company) are: 1) establishing a system of commercial accounts addressed to modern management; 2) achieving the necessary degree of standardization while keeping costs down and complying with national and other requirements for competitive procurement; 3) designing tender evaluation procedures that take nonprice factors into account; 4) introducing automation (e.g., subscriber trunk dialing) without incurring excessive congestion due to the increased use stimulated by these improvements; and 5) ensuring good project planning, coordination, and control. Problems of implementation also arise at the level of the telecommunication sector as, for example, in establishing expeditious and effective relationships between the telecommunication companies and national entities that have regulatory powers over investments, external financing, tariffs, or national industries. Finally, there are problems of implementation at the level of the environment, such as when trying to adapt personnel structure, numbers, and remunerations to labor market variations and to the evolving system's size and scope, in the context of national policies restraining public sector employment and salaries. Most of the problems of implementation, and especially those at the level of the institution, have solutions that apply equally well to different situations and to a number of countries. However, the solutions have been developed gradually by staff in the countries themselves, by consultants, and by international technical and development organizations and their findings are rarely published. A telecommunications handbook for developing countries, which would collect and organize this wealth of very relevant expertise beyond the trivial generalities of introductory texts, is greatly needed.

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Problems of implementation are handled by drawing on established knowledge and practices and on experience in similar situations. There are, however, other problems for which solutions are based more on intuition than sound knowledge of the process involved, which is lacking and where considerable theoretical and field work is needed before solutions of any permanence and general validity may emerge. These we will call problems of method.

The remainder of this paper discusses briefly four classes of problems of method (there are others): demand forecasting and the impact of uncertainties on system design, cost, and performance; project evaluation and the allocation of priorities; pricing; and technological dependence.

II. FORECASTING PROBLEMS

In developing countries, it is common to find a wide disparity between actual connection and traffic demands on the one hand and the respective forecasts on the other. In countries that have the human resources (managerial and technical) and financial capacity, these diverging paths are rapidly identified and acted upon in time to modify the project as needed. In such cases, the resultant capital cost does not seem to be any higher than if more accurate forecasts had been initially available, and degradation of service is small, localized, and temporary with little or no loss of revenue.

An example of this type of situation occurred in the Republic of China's 1966–73 telecommunication program, which was initially designed to cope with a forecasted 16 percent annual growth of demand for new telephone connections. It was soon realized that this estimate was too low. The project was modified accordingly in 1969 and the local networks expanded from 113 000 subscribers in 1966 to 487 000 in 1973 (Fig. 1). This resulted in an average annual connection growth rate of 23 percent, the highest in Asia during that per-

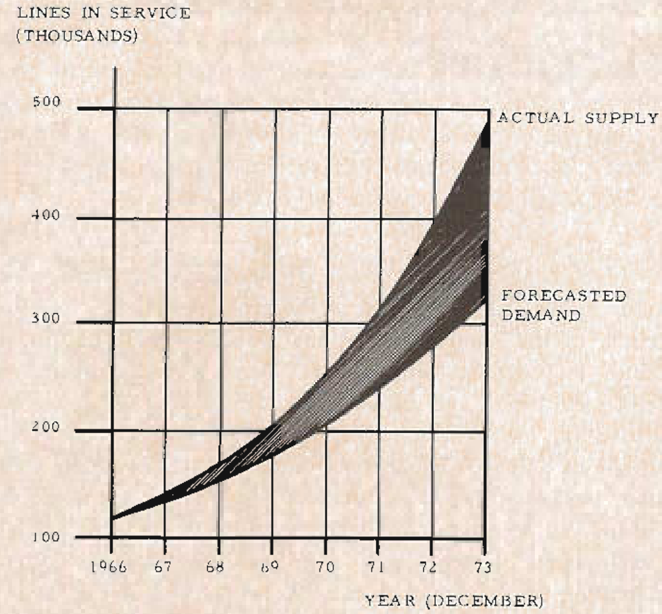

Fig. 1. Forecasted demand and actual supply of subscriber telephone lines in service (Republic of China, 1966–73).

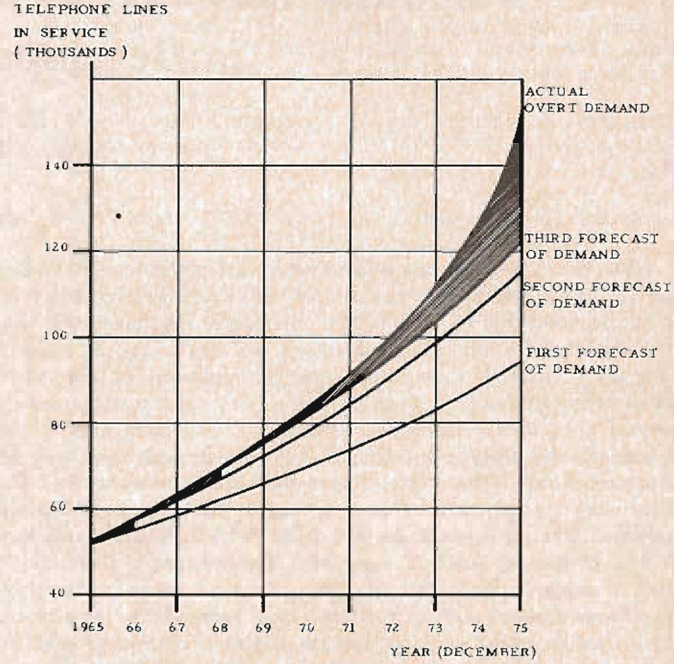

Fig. 2. Actual and forecasted telephone connections demand (East African Community, 1965–75).

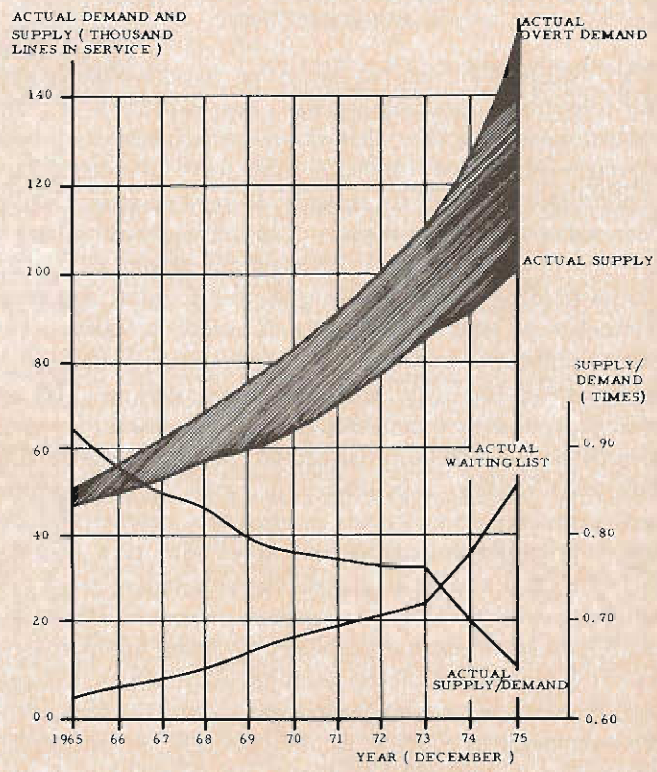

Fig. 3. Actual demand and supply of telephone lines in service (East African Community, 1965–75).

iod. A growth of 27 percent was realized in 1973, probably a world record. To some extent due to this accelerated expansion, and the introduction of subscriber trunk dialing (STD), trunk traffic grew at 25 percent per annum instead of the 15 percent forecasted, resulting in trunk network congestion. Insufficient capacity prevented STD from being extended nationally as fast as programmed and a number of local offices with STD equipment already built into them had their cutover into fully automatic trunk service delayed pending the completion in 1973–76 of a new microwave system not included in the original project. Nonetheless, the deterioration of service quality, equipment subutilization, and revenue losses, while significant, were moderate and temporary.

Not many developing countries, however, are as well prepared to adapt their telecommunication programs to large differences between actual and forecasted patterns of connection demands and traffic. Program rigidities combined with large forecasting errors may lead to substantial and extended deterioration of service quality, a widening gap between supply and demand, excessive equipment wear and tear with reduced capital life, substantial revenue losses, and engineering problems of mounting difficulty.

An example of this type of situation occurred in Kenya, Tanzania, and Uganda's 1966–74 joint telecommunication program, which was originally designed to satisfy a 6 percent growth in telephone connection demands. This estimate proved too low and a new program was designed for an 8 percent demand growth, and then redesigned again for an 8½ percent demand growth. In practice, however, demand over the 1966–74 period ranged from a low growth of 8.4 percent to a high of 15.3 percent, or a 10.5 percent average annual growth rate (Fig. 2). Although supply rose at 7 percent per annum (somewhat above the original demand forecast), by the end of 1974 the waiting list equaled to 36 percent of the lines in service, which was equivalent to the previous six years' net additions (Fig. 3). Based on the 6 percent growth of connection demands, an 8 percent growth in trunk traffic was initially forecasted. However, the trunk traffic actually increased at 19 percent per annum, partly brought about by the introduction of STD (Fig. 4). In addition, the average call duration was also underestimated. The result was an average traffic per sub-

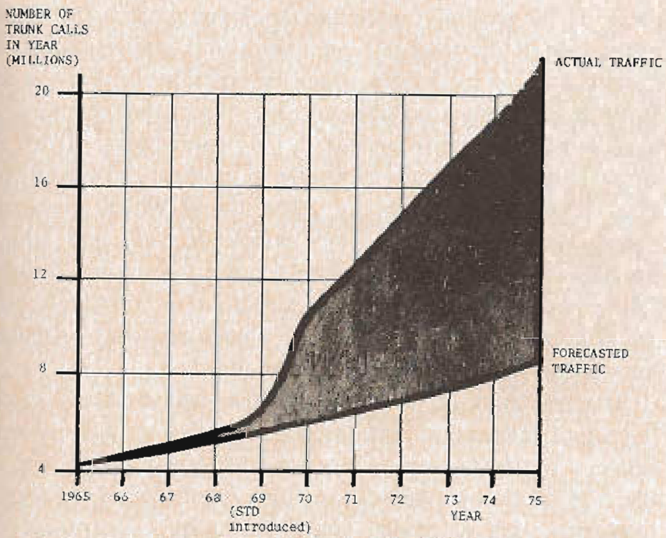

Fig. 4. Actual and forecasted number of trunk calls (East African Community, 1965–75).

scriber line well in excess of the equipment's design targets. Compounded by construction delays, heavy congestion ensued: in main cities, as little as 29 percent of local call attempts and 10 percent of outgoing trunk call attempts were being completed. The repeated call attempts increased the probability of incompleted calls and worsened switch occupation, which was already high as a result of increased use per telephone due to slow supply of new installations. Thus, repeatedly low forecasts for connection and traffic demands, combined with construction problems, resulted in supply increasingly lagging behind overt demand, very high levels of congestion throughout the system (posing a considerable engineering difficulty in designing an effective and economical relief program), associated users' dissatisfaction, substantial losses of revenue for traffic not carried, and equipment wear well beyond what would normally result from handling the traffic actually carried.

Sometimes it is apparent why the forecasts were so wrong. In China, at the outset of the program, the country experienced an unprecedentedly large growth in manufacturing, public utilities, construction, number of registered motor vehicles, and rail and road passenger traffic and freight, which were probably all strong telecommunications users. At the same time, sectors that were weak telecommunication users (e.g., agriculture, mining) grew much slower, or even decreased their output. In the late 1960's, the contribution of manufacturing to gross national product (GNP) surpassed that of agriculture, industrial activities became quite sophisticated, and the overall pattern of economic activity acquired an unexpected complexity that brought changes in structure as well as volume. Structural change and increased contact among sectors and across regions are all factors that can be expected to exert strong pressure on telecommunication services. These major changes in the economy had not been foreseen and the forecasts probably did not take them into account; China's fourth five-year plan was based on a real GNP growth target of 7 percent per annum, whereas actual growth rose from 8.6 percent in 1966 to 9.3 percent in 1968 and to 12.3 percent in 1973. Other factors that may have been overlooked were the possible existence of a substantial hidden demand for telephone connections that became overt only once the system really got moving, and allowance for the large impact on traffic brought about by the generalization of automatic local subscriber dialing and, later, by STD.

In the community of East Africa, the initial estimates were based on post-independence data, which reflected an unusually stagnated period in the economies of these countries, and, therefore, did not take into account the substantial growth which followed in later years. Hidden demand was known to exist at some time in the business sector, limiting the extent to which the waiting list actually reflected unsatisfied demand. A similar situation may have been present in the residential sector as well. The choice of 6 percent growth in telephones was, however, probably in line with international experience at that time. For instance, using Kenya's population and GNP growths for 1967–68, the CCITT's "Economic Studies at the National Level in the Field of Telecommunications" would have predicted a 6 percent growth in supply.

In general, telecommunications forecasting in developing countries is unsatisfactory. In most cases, the following questions are especially pertinent. Why is it that telecommunications forecasting is so grossly inaccurate, while this is not the case in other fields, such as electric power? Is it that existing forecasting techniques are inadequately applied, or are they themselves essentially not suited for the conditions in which they are used? To what extent are large forecasting errors unavoidable because they relate to the difficulty in predicting the countries' overall economic and social paths? And, if forecasting errors are to a great extent unavoidable, how does this reflect on system design? What is a "least cost solution" in the presence of great uncertainty about the needs? How does one build in, and value, system flexibility beyond what is normally achieved by straightforward design?

The problems of finding the ultimate limitations of forecasting in the early stages of systems, improving prediction techniques to approach the best that can reasonably be done, and elaborating on the question of optimal economics and engineering of system design under large uncertainty, essentially have not been solved and remain the weakest points in telecommunication systems planning and design in developing countries.

III. ECONOMIC EVALUATION PROBLEMS

In most developing countries, telecommunications expansion is limited mainly by supply, rather than by demand, as reflected in waiting times of several years for new connections in a number of countries (Fig. 5). Supply is mostly limited by constraints on human resources (both technical and managerial), and by the countries' modest capacity to generate capital for new investments. Thus, allocation of priorities for expansion within the telecommunication sector becomes a crucial question. Given very limited resources for telecommunications, how can they best be used?

To answer this question in a rational manner requires knowledge of the costs and the benefits associated to alternative feasible project packages. The components of cost are well

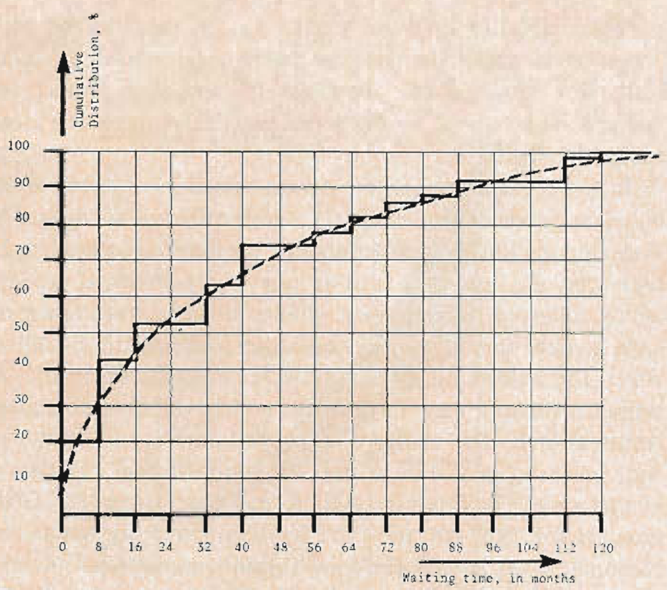

Fig. 5. Cumulative distribution of waiting time of standing orders for residential telephone connections in Greater Santiago, Chile (June 1967).

identified and their valuation at market prices is straightforward. However, the price system is often very distorted, especially with respect to the prices of labor, capital, and foreign exchange, and shadow prices must be estimated, posing considerable difficulties. The situation in calculating the benefits is far worse. Not only is it generally unknown how to quantify them, but benefits are not even clearly identified as to their nature.

Given these difficulties in assessing costs and benefits, alternative projects are usually evaluated only in terms of their technical and financial viability, selected to yield high financial rates of return on capital (qualified by political and more or less intuitive social and other considerations), and realized in ways which at best result in least costs at market prices. With few exceptions, technical and financial constraints (including achieving a reasonable rate of return on capital) leave open a number of rather differently oriented choices, and thus the political and subjective factors receive an unduly high weight in the final program selection.

A relevant example on priority allocation problems within the telecommunication sector is found in Colombia, which, in 1974, had about 800 000 telephone subscribers in the cities, but very few in the small towns and villages. In 1975 a fund was established for receiving a fixed share of long distance and interuational revenues to provide rural service. Considering that one of Colombia's presistent economic development problems has been the small proportion of population that is able to participate in this development and in its benefits, and the fact that the country's vast agricultural and mining potential has been tapped only to a small extent, how is it that a vigorous rural telephone program did not receive high priority much earlier in Colombia's long record of sustained telecommunications improvement and expansion? With a rural program now expected to gradually serve several thonsand small settlements at a total cost of some $40 million (U.S. equivalent), what is its likely impact on the rural economies and on cultural and social integration among the settlements and with the wealthier and more developed urban areas? What proportion of the total telecommnnications investment effort should go to the rnral areas, where the social benefits are likely to be large although possibly a proportion of the users cannot pay the full cost of the services? Is the financing share right, or would it be economically advisable to increase this subsidy of rural telecommunications by urban users? Which towns or villages should be served first, which delayed, and which dropped from the rural program for the foreseeable future? These and other very relevant questious on rural telecommunications cannot be answered objectively with available knowledge—neither in Colombia, nor elsewhere.

The weakness in understanding the economic and social impact of telecommunications makes it also virtually impossible to justify telecommunication investment objectively in the face of strong competition from other sectors for scarce resources, such as capital contributions by Government or those obtained as credits and loans from multilateral development organizations. The latter, in turn, have little objective argument in favor of sustaining an important telecommunications lending effort. The situation is made worse by the absence of input–output data showing the amount of telecommunications used by other economic activities. Thus it is usual to find, in developing countries, thar telecommunication programs are designed with no reference to programs in other sectors, either at the stage of determining the composition of the telecommunication program or in the latter's economic justification and related claims on scarce resources. Conversely, programs of integrated development for parts of countries or regions rarely, if ever, include a telecommunications component. For insrance, rural development programs refer to such public utilities as water, electricity, and transportation, but not telecommunications!

There are direct engineering implications of these weaknesses in economic evaluation. Investment allocation decisions within the sector determine the telecommunication system's growth pattern and its engineering. Alternatives considered iu practice often imply only different conventional combinations of standard equipment packages (e.g., exchanges, radio links). There are situations, however, where chauges in allocation criteria may lead to unusual system requirements. An important case is again found in rural telephony, where developing countries have tended to follow the indnstrial nations' practice of providing rural coverage as the last and farthest component of the complex urban and interurban system, once the latter has reached a considerable size and copes well with demand. While this may be right in essentially urban countries, it is not so in others where as much as 90 percent of the population lives on agriculture and will continue so for the foreseeable future. Most likely, economic evaluation of alternatives would result in programs which, while expanding the strong reveuue-earning urban and interurban services (thus ensuring the financial viability of the sector as a whole), would place earlier and larger emphasis on rural networks. This changed emphasis could, in turn, stimulate an innovative design and manufacturing effort addressed at the essentially different service and technical requirements of rural communications which stem from the specific sociological and economic characteristics that make rural life in many countries a form in its own right.

Although there have been some exploratory studies on telecommunications economic problems in developing countries, methodologically this remains a very weak area. The following questions, among others, remain unanswered. Which are the main economic functions for which telecommunications are an effective, efficient, and acceptable means? How much telecommunications are used by each other economic sector at different stages of development? What is the impact of telecommunications on structural, as different from marginal, economic, and social changes? Which components of benefits can be quantified in monetary terms, and what are reasonable criteria to do this? To what extent can economic costs and benefits analyses, apparently better developed in other sectors (e.g., power, transportation), be applied or adapted to telecommunication project evaluation? What is, objectively, the role of telecommunications in the development of regions and nations?

IV. PRICING PROBLEMS

Pricing is at the center of several of telecommunications' problems of method. For instance, it affects forecasting insofar as prices influence connection demands and traffic which, in turn, affect the size and technology chosen for the system, and thus its unit cost, to which prices are related. It relates to the allocation of resources to the telecommunication sector and within it to the extent that available economic theory indicates certain pricing criteria that could lead to economically optimal allocations.

In developing countries, however, tariff structure is usually the outcome of a historical process mainly reflecting at best a very rough appreciation of the localization of the major cost items across the network, common sense, political pressures, and intuitive social and other considerations. Telecommunication programs almost without exception revise tariffs only regarding their level, adapting it to ensure sufficient revenues to cover expected operating expenses, debt service, depreciation, and some surplus for expansion. Tariff structure is seldom looked into, except to see it is not way out of line with practices in other countries. The cost structure is unknown, and large hidden subsidies within the sector are probably the norm rather than the exception. Applications of economic theory to orient telecommunication tariffs design are virtually unknown, although considerable effort has taken place along such lines in other sectors (e.g., electric power).

Questions on pricing also arise in relation to more transitory aspects of system development, such as capital formation and plant utilization. For example, is it economically right to keep tariffs at a level which, although they yield a reasonable rate of return on capital, result in demand for new telephone connections that are way above supply capacity, year after year, while the supply is often prevented from growing faster precisely by insufficient capital for expansion? To what extent can changes in tariffs influence utilization of existing equipment in order to prevent or alleviate congestion by bringing user habits into line with normal design targets? When service is started in countries or regions where it is virtually unknown, what is an appropriate price strategy that while addressing itself in the long term to economic optima, facilitates the diffusion of innovation and its incorporation to the economic and social processes it is meant to support?

V. TECHNOLOGICAL DEPENDENCE PROBLEMS

Telecommunication programs in developing countries depend substantially on foreign technology. Some countries need outside assistance in defining needs, preparing basic plans and programs, implementing project engineering, procurement, and installation, and supplying staff for key management, maintenance, and operations posts. Most developing countries, however, are better off than this and require external expertise only to complement *some* aspects of their own work; a few are as professionally competent and independent as could be expected anywhere. With few exceptions, though, developing countries have little or no telecommunications equipment manufacturing. Whatever they do have is based primarily on foreign design and experience. This industrial dependence is likely to continue for some time. Some factors that result in these diverse forms and levels of dependence relate to general and higher education, recruitment and training, institutional organization, research and development, and the characteristics of markets open to the country. Most of the problems arising from the desire and economic convenience of decreasing this dependence are problems of implementation, not of method. Among the latter, however, two are of particular interest and I will introduce them briefly now: the question of technological innovation, and that of the role of research and development.

Telecommunications is a field of very rapidly changing technology. New techniques appear faster than the capital lives of major parts of a telecommunication system are expended, and, from time to time, genuinely new service and system structure concepts emerge as well. This has a large bearing on system design. Solutions selected today to yield least costs over their expected life spans may soon be found uneconomical to retain in the face of new ones that have become available. Short-term least cost is not equal to long-term least cost: maximizing economic and technical convenience over a long period requires building into system design a capacity to adapt to technological change, and this implies an added short-term cost. In developing countries, this problem comes in addition to the need to build in flexibility to adapt to unforeseen demand and traffic patterns, as discussed earlier. Yet, solutions typically assume no forecasting error margins and no change in available technology. There is clearly much to be done in dealing jointly with demand forecasting, technological forecasting, and system optimization under uncertainty.

For countries that depend almost entirely on industrial nations for the supply of equipment, the rapid pace of telecommunication technology presents a dual problem. On one hand, if they are to adopt a new system concept or major technique, they must do so rather early in order to utilize it fully before it is superseded by new developments and phased out industrially at its source; on the other hand, some techniques no longer used in industrial countries may continne to be the only ones available for some important uses in nonindustrial contexts (e.g., magneto telephone systems for towns and villages with no regular electricity supply). This dual technology problem involves high costs and risks of early adoption of new solutions, and high costs of obtaining discontinued types of equipment. The ways out of this have not been fully explored, especially in what pertains to industrialization of the developing countries. Should old types of equipment, for which technology is public domain anyhow, be manufactured locally or regionally to reduce costs? Does such an approach imply that the less industrialized nations will continue to be so by producing what is no longer wanted elsewhere? Or is there scope for using new technology to develop modern solutions to meet the unique needs and characteristics of parts of the developing nations' systems?

The last question has a bearing on the second subject, namely, the role of research. Clearly no developing country (nor any but a few of the largest industrial ones) can expect to become technologically self-sufficient in *all* fields of industry. However, in order to attain a balance between economic freedom and interdependence, developing countries must become self-sufficient in *at least some* domains of technology. To this end, research has a number of important roles to play. Among them, two are outstanding: 1) research is a key factor in building up and sustaining a country's capacity to follow, understand, evaluate, adapt, and adopt exogenous technology; and 2) it is a fundamental and irreplaceable source of autonomous solutions to engineering and industrial production problems, especially when addressed to the needs and conditions that are somehow unique or typical to the country. Therefore, the question arises whether a given country should aim at being at least partially autonomous in telecommunication technology and, if so, does it adopt early enough appropriate policy decisions, establish the required institutional framework, and allocate resources as needed for effectively interrelated research, development, and production efforts? So far, very few developing countries have dealt with telecommunications in such a comprehensive way. The scientific, industrial, and related economic aspects of telecommunication programs have rarely been explored, and thus important long-term potentials remain untouched.

VI. CONCLUSION

These and related problems of method give rise to the need of looking at telecommunications from the viewpoint of the human functions they may support. Such a viewpoint is certainly not provided by the engineering sciences and profession. Whereas a number of other disciplines have important contributions to make to the understanding of telecommunications as a social factor, none of them alone provide a sufficiently broad, yet precise, framework. Thus, it is not a matter of hiring an economist, a sociologist, or a psychologist, to do the job engineering cannot undertake by itself, but it becomes essential to have expertise from a variety of engineering, social, and behavioral sciences interacting in mutual understanding and contributing jointly to the analysis of and solution to problems to which they are relevant. Thus, to deal with telecommunications as a factor of the community's endeavor, it becomes necessary to adopt a truly *interdisciplinary* approach.

The nature of the hnman resources needed to deal with these problems of method, the time scale required to achieve results of some permanence, and the variety of real situations to which access is needed to ensure a reasonably broad applicability of the findings, make it unlikely that any one developing nation will undertake a sufficiently deep and comprehensive study of them. On the other hand, industrial countries that might command the necessary expertise and material resources, are not likely to give these particular problems of underdevelopment a high priority. Thus, it appears that the few international organizations that have a rich experience in telecommunications in developing countries are in a unique position to undertake systematic telecommunication sectoral interdisciplinary studies which may yield gradually powerful instruments to assist the best use of scarce telecommunication resources in developing countries. A few international development banks and agencies, and the International Telecommunication Union, may well be the only ones that could do this in the foreseeable futnre.

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Björn Wellenius, for a photograph and biography, see page 290 of the March 1976 issue of this TRANSACTIONS.