CHAPTER 2
SIGNIFICANCE OF SRI LANKA LONG TERM TELECOMMUNICATIONS PLAN AND SERVICE STATUS QUO

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CHAPTER 2 SIGNIFICANCE OF SRI LANKA LONG-TERM TELECOMMUNICATIONS PLAN AND SERVICE STATUS QUO

1. SIGNIFICANCE OF SRI LANKA LONG-TERM TELECOMMUNICATIONS PLAN

1.1 General Conditions of Sri Lanka

1.1.1 Topography, Population, Climate

Sri Lanka is a tropical island country located in the Indian Ocean south-southeast of India. Geographically, the country occupies a pivotal position in East-West maritime traffic that connects Europe, Africa and the Middle and Near East, on one hand, and Southeast Asia and East Asia, on the other. In this connection, especially important is the role which Colombo, the capital city, performs.

Population as of 1985 is estimated at 15,900,000. National area totals 65,610 km^2. Population density is relatively high at 242/km^2.

Up to 73% of total population are Sinharis, 19% are Tamirs and the remainder are other tribes.

Climate is the typically tropical climate consisting of wet and dry seasons. Temperature is high in wet season, i.e., March to June, but is low in dry season of November to January. In Colombo that faces the sea, mean temperature is 27°C with annual variation limited to 6°C. At Nuwara Ehiya in the central part of the country, where height above sea level measures 1,890 meters, mean temperature is as low as 16°C.

Rainfall is plentiful in the southwestern sector where maximum annual precipitation exceeds 3,000 mm. In northern, eastern and southeastern sectors, mean annual rainfall is limited to not more than 1,000 mm. The former is called the wet zone and the latter the dry zone.

1.1.2 Economy

In Sri Lanka, Gross Domestic Product (GDP) per capita as of 1983 ranks 24th from bottom in the world list of 125 countries. This is the World Bank announcement in its world development report.

However, since the United National Party (UNP) assumed power in 1977, the national economy is attaining unprecedently rapid growth, supported by the liberalization policy introduced by the UNP administration. Average annual growth rate of real GDP, which was 2.9% during 1971 through 1977 and 4.4% during 1960s, improved to 6.0% in the period from 1978 to 1983. Since the population growth rate was at relatively low level of 1.7%, compared with other developing countries, real GDP per capita growth rate during 1978-83 stood at 4.1% or more than three times the corresponding growth rate during 1970-77. Unemployment ratio also improved from 25.0% in 1977 to 14.7% in 1983.

Sri Lanka economy remains agriculture oriented to a great extent. As of 1984, agriculture takes 28% share out of total GDP and farm workers number about half the total gainfully occupied population.

However, on account of steady progress of the administration policy to get rid of monocultural pattern of economy wherein agriculture performs central role,

industrial development is pulling up momentum. In GDP record for 1984, agriculture registers annual growth by not more than 4.0% whereas mining and manufacturing industry presents good showing with 14.7% growth; even service sector follows suit with 5.6% growth.

Thus, in wide departure from traditional agriculture orientation, Sri Lanka economy has come to find its vital force in industrial production. The administration policy to promote such reorientation of economy appears to be functioning as scheduled.

The Sixth Revised Five-Year Public Investment Plan (1984 - 1988) is to make priority investment in the undermentioned sectors.

(1) Quick yielded production. The purpose is to earn foreign currency by such export and spend it for bolstering full industrial production so as to eliminate industrial product import pressure.

(2) Economic infrastructure. Power generation, irrigation, transport and communication.

(3) Social infrastructure. Medical service, education, housing and food production sector where urgent investment is required.

Especially in communication sector, numerically greater expansion than in power generation, irrigation and transport sectors has been realized during the past five years. Nevertheless, the expansion still leaves room to be desired qualitatively, and this means that further investment is necessary with a view to qualitative improvement of the whole system so that it can function successfully as the foundation of economy.

1.2 Significance of Long-Term Telecommunications Plan

1.2.1 Necessity for Long-Term Plan

The foregoing report in the public investment plan indicates that the national telecommunications network improvement and expansion projects, to cater for rapid telephone demand growth during five years before 1984, is not raising as much effect as planned. The reason is that the network improvement and expansion plan is not exactly guided by clearcut long-term objectives, causing investment to be out of balance for the whole system in more cases than not. Therefore, from the viewpoint of effective work execution from now forward, it is most important for and urgently required of SLTD to formulate carefully arranged Master Plan as long-term basic plan.

1.2.2 Interrelation Between Economy and Telecommunications

As is a proven fact in the developed countries, the advancement of economy and the progress of telecommunications are intimately interrelated. As telecommunications facilities are improved by means of new technology introduction and diffusion rate increases as the result of additional installations, exchange of information with greater reliability and on more extensive basis than before becomes possible. In other words, people who utilize telecommunications can benefit a great deal from such exchange of information in the effective use of resources including partially developed and wholly undeveloped resources. Furthermore, they can perform economic activities without loss, hence, at high efficiency. A foregone conclusion is that telecommunication facilities upgrading is bound to revitalize national economy of Sri Lanka and support its further development, increasing employment opportunities in all industrial sectors.

Master Plan for telecommunications system upgrading should be all-inclusive: it should identify new technologies and new services to be introduced according to the requirement from the national industrial development as one of economic infrastructures. That is, it should identify the policy for industrial development in some cases. Thus the most important requirement in Master Plan formulation is to forecast developmental trends of Sri Lanka economy. That is to say, Master Plan should reflect future vision of Sri Lanka telecommunications services and even imply the mode of development of Sri Lanka economy.

2. SERVICE STATUS QUO

2.1 Demand Trend

These days, in Sri Lanka, such life conveniences as electricity and TV are diffused even among remote mountain areas so that daily life pattern shows signs to become diversified. Perception of inhabitants toward telecommunications is improving and demand for telecommunications service in recognition of personal and social benefits is increasing.

Telephone diffusion is spreading from among public organizations to among general households. The latter's share in telephone demand occupies ever-growing percentage. During 1982-83, telephone demand recorded rapid growth by 13.3%. Newspapers report almost everyday about demand from citizenry for expansion of telecommunications media.

To cater for such demand without delay, both qualitative and quantitative improvement of telecommunications system constitutes urgent requirement.

2.2 Operating Entity and Organization

2.2.1 Operating Entity

In Sri Lanka, telecommunications service including overseas service is under responsibility of SLTD that belongs to Ministry of Posts and Telecommunications. Formerly, both postal and telecommunications services were under control of Posts and Telecommunications Department; however, in August 1980, SLTD came into being to assume sole responsibility for telecommunications service.

2.2.2 Headquarters Organization

At present, SLTD Headquarters top management is composed of Director and seven Deputy Directors plus Chief Accountant. In-depth organizational chart appears in Figure 2-1.

Under each Deputy Director, Chief Engineer(s) with his (their) assignment is posted.

As of the end of 1982, number of SLTD staff employees were 9,549. Breakdown is as under.

Administration	734
Accounting	206
Engineering	5,911
Traffic	2,154
Transport	247
Stores	297
Total	9,549

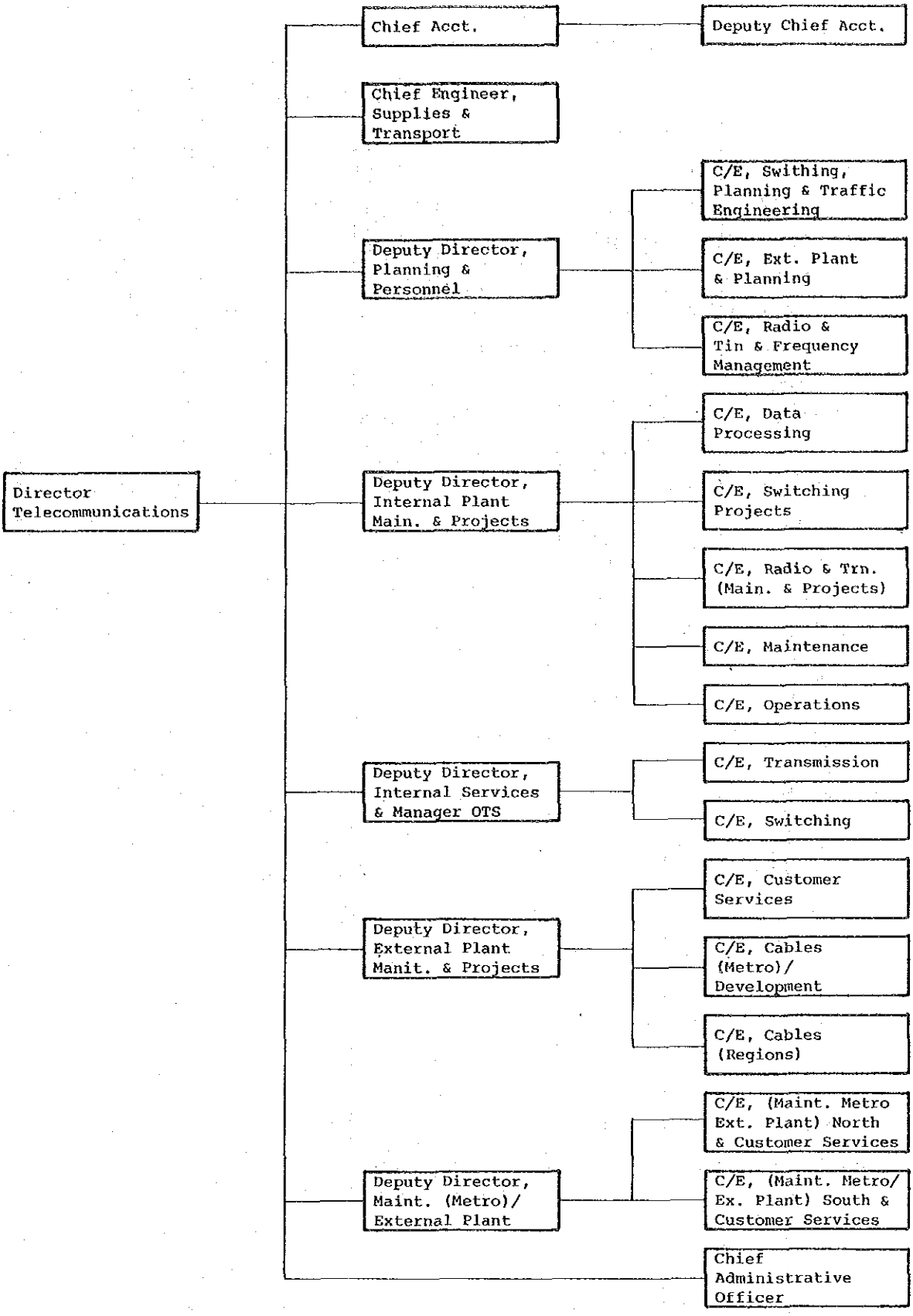


Figure 2-1 SLTD Organization

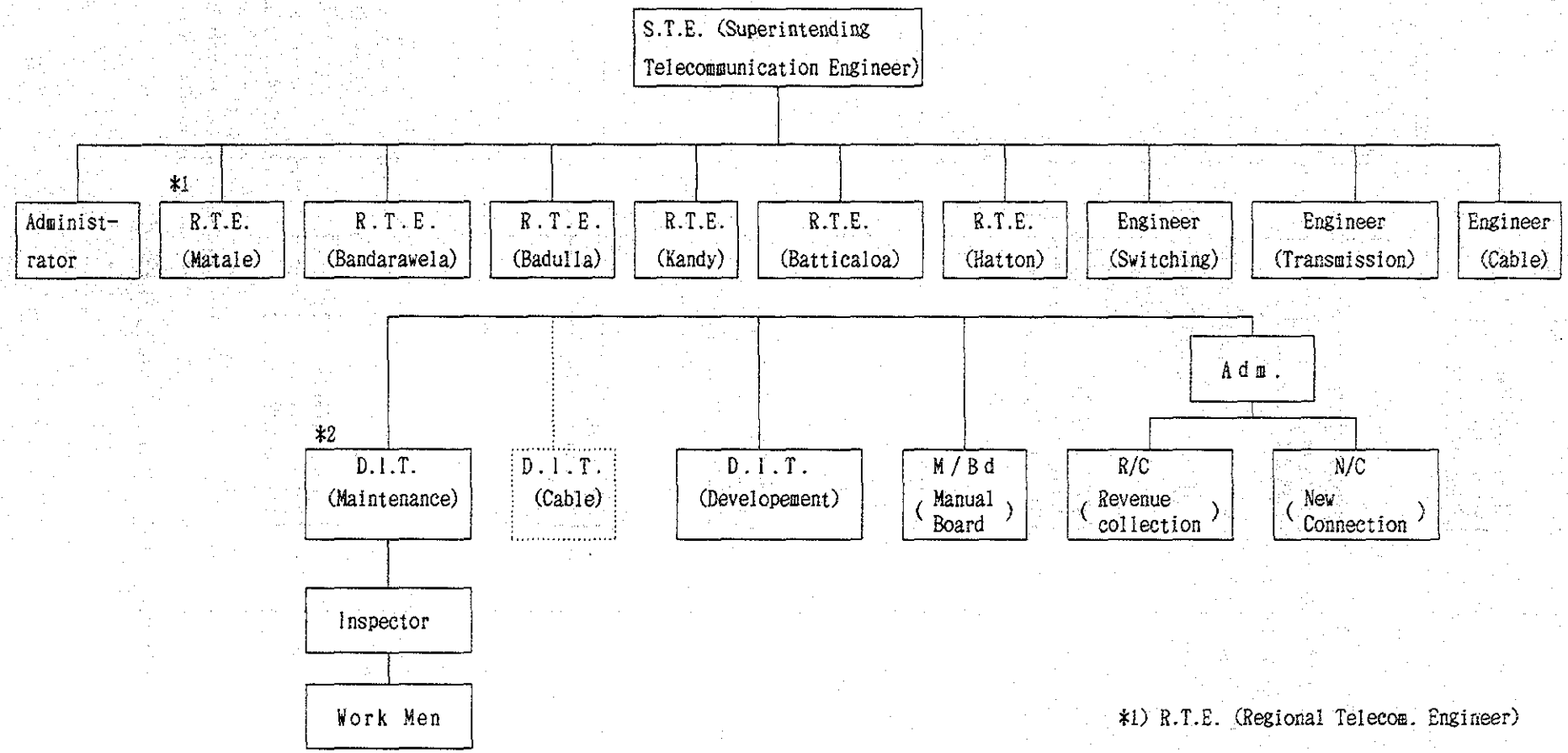


Figure 2-2 Kandy Area Maintenance/Operation Organization

2.2.3 Regional Organizations

Under SLTD Headquarters are established Regional Organizations to control several district exchange areas. Regional Organizations are at Colombo, Kandy, Galle and Anuradapura. Organizational chart of Kandy Regional Organization as typical example is given in Figure 2-2.

Kandy Regional Organization is headed by STE (Superintending Telecommunication Engineer). Under STE are posted RTEs (Regional Telecommunication Engineers). Besides RTEs, Engineer (Switching) who takes care of switching operation control in the whole region, Engineer (Transmission) who is in charge of transmission control, Engineer (Cable) who is responsible for construction/maintenance of cable system out of all outside plants, and Administrator are also posted under STE.

At each exchange office, RTE keeps under him responsible personnel for various engineering sections. Again, the personnel lineup at Kandy Office is used as typical example. The lineup consists of DIT (Maintenance) (District Inspector of Telecommunication in charge of maintenance of aerial cable system out of all outside plants and subscriber's premise equipment), DIT (Cable) (ditto in charge of cable system construction/ maintenance; see note below), DIT (Development) (ditto in charge of construction and development), Chief of Manual Board Operation, and Administrator. Administrator comprises two types, i.e., R/C (Revenue Collection) and N/C (New Connection). The former is in charge of billing and collection; the latter takes care of new telephone installation.

Note: At Kandy Office, DIT (Cable) is organized as upper structure so that it is not under control of Kandy RTE.

2.2.4 Service Status Quo

(1) Service Categories Provided

Service categories provided and service records are in Table 2-1.

Table 2-1 Service Categories Provided and Service Records

	Service Category	1983 Record
Telegram	Inland service Overseas service	3,008,000 messages 459,000 messages
Telephone	Inland service Overseas service	200,000,000 calls 465,000 calls
TELEX	Outgoing service Incoming service	760,000 times 1,940,000 times

Besides service categories mentioned in Table 2-1 which are provided by contract between SLTD and each subscriber, private communication service centers are operating at several places in Colombo City. These service centers provide inland and overseas telegram, telephone and TELEX services to the public through SLTD network.

(2) Operating Facilities and Diffusion Rate

Operating facilities of telecommunications and diffusion rate as of the end of 1983 are in Table 2-2.

Table 2-2 Operating Facilities and Diffusion Rate (as of end of 1983)

No. of subscriber circuits (A)	71,432
Telephone diffusion rate ((A)/100 inhabitants)	0.46
No. of telephones installed (including extensions)	109,900
No. of demand	105,005
No. of switching equipment line units	131,466
No. of subscribers on waiting list	33,573
No. of telex subscribers	967

Telephone diffusion rate of 0.46 as given in Table 2-2, when expressed in the rate against the number of telephones installed (including extensions) becomes 0.71 per population of 100. This rate is above 0.5 of India and Pakistan, respectively, but below 1.1 of Thailand.

(3) On-going Network Improvement Projects

Telecommunications development plans of Sri Lanka comprise two main types. They are:

A. CADS (Colombo Area Development Scheme) Project

B. OCADS (Outer Colombo Area Development Scheme) Project

CADS Project is for local network improvement mainly in Greater Colombo Area. As of the present, Stages II and III are in progress. For Stage IV, tender was closed in May 1984 and evaluation of submitted bids is now being carried out by SLTD. OCADS Project is for rural network and toll trunk network improvement. At present, IDA project financed by IDA (International Development Association) loan is in progress.

In all cases, project implementation is to be financed by government budget plus external, including foreign loans. However, available funds from these sources fall short of actual requirements so that SLTD cannot proceed ahead with project implementation as initially planned. Thus, for project implementation, decision has been made to begin with project for which necessary budget becomes available.

Main telecommunications network improvement plans in Sri Lanka are in Table 2-3.

Table 2-3 Main Telecommunications Network Improvement Plans in Sri Lanka (1/4)

Project Name	Initial Year	Remarks	Completion Year
CADS-I	1960	o British loan o British GEC and STC Stroger switches installation at 20 exchanges, with cable laying o In the course of installation work, British contractors withdrew. SLTD succeeded and completed the work without outside assistance.	1968
CADS-II	1978	o CIT-ALCATEL (E10B) installation (French fund) o Subscriber's line extension by 28,150 line units, including renewal of time-worn SXS switches in Greater Colombo Area; PCM equipment installation; local cable replacement with plastic cable o 6-digit dialing system for local calls	1981 (Phase 1)
CADS-III	1982	o CIT-ALCATEL (E10B) installation o Havelock Town Exchange and Remote Exchange subscriber's line extension, 21,750 line units	
CADS-IV (scheduled)	1984	o Tender in May 1984 o Subscriber's line extension by 32,000 line units, including renewal of time-worn SXS switches of Colombo Central and Maradana Exchange	1987 (scheduled)

Table 2-3 Main Telecommunications Network Improvement Plans in Sri Lanka (2/4)

Project Name	Initial Year	Remarks	Completion Year
OCADS-I	1966	o Suppliers' credit from NEC, Fujitsu and Fujikura of Japan o Approx. 12,000 circuit XB switches installation at 18 DSCs and NSCs in 13 cities; 6-hop microwave system construction	1973
OCADS-I	1975	o Colombo DSC capacity expansion (C400); NEC Company	1976
OCADS-II	1979	o NEC and Hitachi of Japan o Yen credit o Digital switches (2,800 T + 7,460 L) installation at 7 exchanges (Anuradapula, Badulla, Kurunegala, Ratnapuna, Trincomalee and one other DSCs and Colombo NSC); microwave system construction covering 10 exchanges (3 exchanges with additional installation and 7 newly established exchanges)	1982
IDA		o Local switching equipment expansion and renewal in rural cities, and long distance toll transmission network expansion. Main work items: Outside plant, switches, radio system and towers. Separate contract for each work item. About 15 projects in all.	
(Switching)	1982	o NEC, Japan o Capacity expansion of 6 DSCs covered by OCADS-II; establishment of 9 new exchanges (NEAX 61, 2,527 T + 19,852 L)	On-going

Table 2-3 Main Telecommunications Network Improvement Plans in Sri Lanka (3/4)

Project Name	Initial Year	Remarks	Completion Year
(Radio, Transmission)	1983	o NEC, Japan o Digital microwave system, MUX, etc.	
India-Sri Lanka Microwave System Project	1976	o Naked financial assistance by Indian Government o Rames Walam (India) - Colombo trans-Sri Lanka microwave system	January 1982
Mount Lavinia Project	1977	o NEC, Japan o Local switches (C400, 6,000 L) and PCM transmission equipment installation at Mount Lavinia o Additional 6,000 L installation in 1983	1977
FTZ Project		o Hitachi and Dainichi of Japan o Telephone and telex system provement in Katunayaka IPZ (Investment Promotion Zone)	1980
Cyclone Project	1977	o Hitachi, Dainichi, NEC and Kokusai Denki of Japan o Rehabilitation/reconstruction of cyclone-hit Eastern Region (Ampara, Batticaloa, Poloanaruwa, etc.) and STD service introduction in the region	1980
Training Center Project	1978	o New training center establishment at Welisala, in addition to the existing Moratuwa training center	On-going

Table 2-3 Main Telecommunications Network Improvement Plans in Sri Lanka (4/4)

Project Name	Initial Year	Remarks	Completion Year
WCY Project		o Digital radio network and cable PCM network construction in Gampaha and Hatton areas o RSU construction in Nuwara-Eliya area	On-going
Hambantota Project		o Digital network construction in Hambatota area o 5 master exchanges, 9 RSUs o Digital radio and cable PCM systems o Subscriber's line network	Under planning
Greater Colombo Project		o Junction cable network in Greater Colombo Area between 24 local exchanges o Local cable network expansion of 7 local exchange areas o Japanese loan	Under planning

(4) Maintenance Condition

As of 1983, average monthly failure rate is 39% per 100 subscribers. This high failure rate is bound to worsen further, considering time-worn subscriber's cable network, in particular. Table 2-4 presents failure rate breakdown by equipment categories.

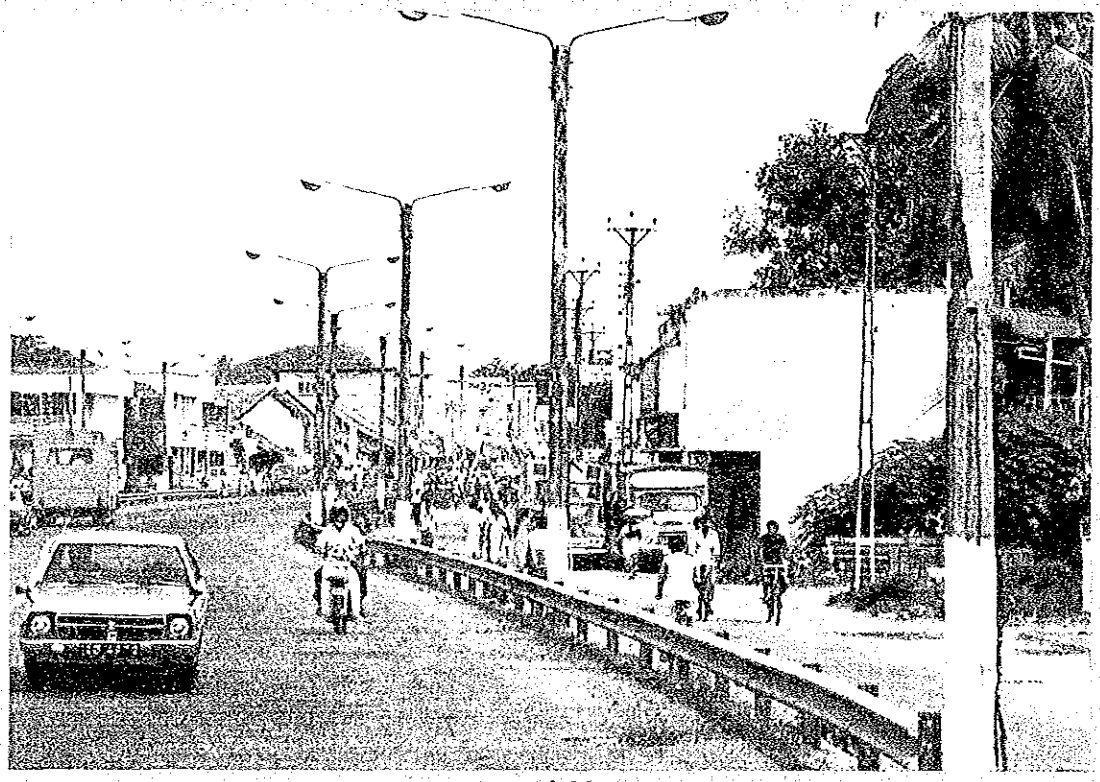
Table 2-4 Failure Rates by Equipment Categories

Equipment Category	Failure Rate (per 100 subscribers) (%)
Office equipment	6.0
Outside equipment, subscriber's premise equipment	71.0
Others	23.0
Total	100.0

Note: "Others" above shows equipment category where cause of failure resides is unidentifiable.

For keeping failure rate at possible minimum level and thus providing high quality communication service, optimum investment plan for project implementation is the first essential. Also indispensable is the exertion to keep project implementation program well organized and its performance at top efficiency.

CHAPTER 3 DEMAND FORECAST



Street of Matara

CHAPTER 3 DEMAND FORECAST

1. GENERAL REMARKS

It is a known fact that telephone demand behaviors depend upon the performance of several factors. Chief among those factors are the vital force of national economy commonly expressed by GDP/GNP, telephone tariff system modus operandi, and national habits and preferences. Correlation formula for telephone demand and its determinants follows:

$$Q = F\ (X, N, P, d)$$

where

Q: Total telephone demand

X: Vital force of national economy, for an example, expressed by GDP/GNP

N: Total population

P: Telephone charges including subscription fee and call charge, etc.

d: Demand growth trend factor considering influence from other factors also

When the above correlation formula is divided by total population (N), the result is:

$$q = F\ (x, P, d)$$

where

q: No. of telephones per unit population (demand density)

x: GDP per capita

P: To remain constant through the future (Actually, P varies according to the currency value fluctuation.)

Therefore, demand density correlates with GDP (x) and demand growth trend factor (d).

Demand growth trend factor is estimated from analysis of the past demand growth plus in-depth study of demand growth stages. Generally, the telephone demand growth stages are divided into initiatory stage, first half of expansion stage, second half of expansion stage, popularizing stage and popularized stage.

In Sri Lanka, telephone demand at present is considered to be in transition from the first half to the second half of expansion stage. Convenience of residence telephones in daily life has come to be widely recognized, causing residence telephone demand to increase rapidly and contributing to the remarkable growth of total telephone demand.

2. TELEPHONE DEMAND FORECAST

2.1 Macroscopic Demand Forecast

Generally employed methods for macroscopic telephone demand forecast are as under.

Step (1) To establish correlation formula from GDP and number of telephones data of several scores of countries, estimated GDP growth of the country concerned, and obtain the number of telephones in the objective year of forecast.

Step (2) To correlate time series data, if available, with GDP or other economic/social activity parameters and thus establish specific correlation formula for the country concerned whereby to forecast demand. And to compare with the result of step (1) and step (2).

For the long term telecommunications system improvement plan of Sri Lanka, the first step is to obtain the preliminary formula, based on records of 56 countries as of the year 1981. The estimated formula in this case is

$$Y = 0.0001154X^{1.372} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

where

Y: Telephone density per population of 100

X: GDP per capita

Then, for the second step, formula (1) is revised, using the visible demand of 0.71 as of the end of 1983. Calculation formula in this case is

$$Y = 0.000329X^{1.372} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

where the demand consists of the sum of the number of operating main telephones and the number of the waiting applicants.

Note: References used for compilation of formula (1) are as under.

(1) World Development Report, 1983 (published by World Bank)

(2) The World's Telephones, 1982 (published by AT&T)

2.2 GDP Estimation

2.2.1 GDP growth rate estimation

GDP to be used in formula (1) is the U.S. dollar equivalent of nominal GDP of the country concerned. The reason is that when GDP at constant factor cost prices is used, the relative value varies broadly, depending upon which year to use as constant year. This is why nominal GDP (at current factor cost prices) is commonly used in telephone density forecast for long term plan.

In Sri Lanka, GDP at current prices increased by annual average of 19.5% during the period from 1970 to 1981. Especially in the latter part of the period, i.e., during 1979 through 1981, growth of nominal GDP at current prices is by as much as 26% annually.

Considering the economic development policy of the Government, nominal GDP growth in Sri Lanka by 26% or thereabouts annually can be expected in the coming years also.

For the purpose of reference, GDP at current prices and GDP at constant prices of Sri Lanka during the period 1970 - 1981 are introduced below.

Table 3-1 GDP at Current Prices and constant Prices

	1970	1973	1974	1975	1976
GDP Current Prices	13,187 (-)	17,920 (21.7)	23,302 (30.0)	25,691 (10.3)	28,032 (9.1)
GDP Constant Prices	13,187 (-)	14,138 (3.7)	14,585 (3.2)	14,987 (2.8)	15,431 (3.0)

	1977	1978	1979	1980	1981
GDP Current Prices	34,684 (23.7)	40,479 (16.7)	49,782 (23.0)	62,246 (25.0)	78,506 (26.1)
GDP Constant Prices	17,078 (4.2)	17,401 (8.2)	18,501 (6.3)	19,575 (5.8)	20,706 (5.8)

(Growth rate compared with the year before in parentheses)
(Source: Central Bank of Ceylon)

GDP expressed in Rupees is then to be changed into the U.S. dollar equivalent.

Since 1977, the Rupees into U.S. dollar conversion is by the floating rate. The Rupees devaluation rate from 1977 to 1982 is 7.3%. Especially during two years from

January 1980 to December 1981, the devaluation rate is 15.1%. Considering the progress of inflation in Sri Lanka, the uptrend of Rupees devaluation will continue for some time to come.

To change nominal GDP expressed in Rupees into the U.S. dollar equivalent, the Rupees value of the year concerned is to be divided by the effective rate of exchange for that year. This, in effect, means (nominal GDP growth rate) - (Rupees devaluation rate again U.S. dollar), or, more precisely,

26% - 15.1% = 10.9%

Thus, for the present long term telecommuncations system improvement plan, the U.S. dollar equivalent of nominal GDP of Sri Lanka is assumed to grow by 10% annually, as under.

Year	1985	1990	1995	2000
GDP (US$)	350	530	800	1,212

2.2.2 Verification by past data

When the demand forecast formula, $Y = 0.000329X^{1.372}$, is applied paradoxically to 1980 through 1983 actual demand (accommodated subscribers + waiting subscribers), x (GDP) can be obtained as under.

Year	Y Value (Actual)	X Value (By calculation)	Growth Rate
1980	0.53	218	9.2%
1981	0.60	238	1.3
1982	0.61	241	13.3
1983	0.72	273	(Average: 7.8)

Average GDP growth rate of 7.8% as obtained above is estimated to become higher in the future.

2.2.3 Future GDP verification

For verification of GDP to be used in the demand forecast formula, GDP at current prices (expressed in Sri Lanka Rupees) for the year concerned as announced by the Government (or Central Bank) has only to be changed into the U.S. dollar equivalent by the effective rate of exchange at the time of conversion.

2.3 Population Forecast

The population forecast for Sri Lanka is in Table 3-3. This forecast is based on population data for the past 11 years(1971 - 1981) (Table 3-2) and utilizes the logistic curve.

Logistic Curve:

$$Y = \frac{K}{1 + me^{-at}}$$

where

K: $30,000 \times 10^3$

a: 0.0315

m: 1.4262

t: Number of years after 1971 as initial year

(Reference)

Statistical Pocket Book of the Democratic Socialist Republic of Sri Lanka 1982, published by Department of Census and Statistics, Ministry of Plan Implementation

Table 3-2 Total Population in Sri Lanka

Year	1971	1972	1973	1974	1975	1976
Population (x 10^3)	12,608	12,861	13,091	13,284	13,496	13,717
Growth Rate (%)	-	2.0	1.8	1.5	1.6	1.6

Year	1977	1978	1979	1980	1981
Population (x 10^3)	13,942	14,190	14,472	14,738	14,988
Growth Rate (%)	1.6	1.8	2.0	1.8	1.7

Table 3-3 Population Forecast in Sri Lanka

Year	1985	1990	1995	2000
Population (x 10^3)	15,900	17,100	18,200	19,300
Average Annual Growth Rate (%)	1.5	1.3	1.2	1.2

2.4 Nationwide Macroscopic Telephone Demand Forecast

Nationwide macroscopic telephone demand forecast obtained by the previously mentioned assumption is as under.

Table 3-4 Nationwide Macroscopic Telephone Demand Forecast

Year	1985	1990	1995	2000
Nationwide Demand Density (%)	1.0	1.8	3.2	5.6
Nationwide Demand	159,000	307,800	582,400	1,080,800
Greater Colombo Area	100,170	193,914	366,912	680,904

3. DEMAND FORECAST FOR TELEX, TELEGRAM AND OTHER NEW SERVICES

3.1 Existing TELEX and Telegram Services

In Sri Lanka, TELEX subscribers as of 1984 number 1,100. Out of them, up to 93% are concentrated in Greater Colombo Area and its suburbs.

Year by year changes in the number of TELEX subscribers during 1977 through 1984 are in Table 3-5. The average growth rate, compared with the year before, is as high as 29.3%.

Table 3-5 TELEX Subscribers in Sri Lanka, 1977 - 1984

Year	1977	1978	1979	1980	1981	1982	1983	1984
Number of TELEX Subscribers	190	262	335	528	719	853	967	*1,100
Growth Rate Over Preceding Year (%)	-	37.9	27.9	56.7	36.2	19.3	13.4	13.8

* including 92 telegraph terminals and 200 international trunks.

TELEX exchanges, besides catering to TELEX subscribers, take care of telegram service also. As of 1984, such service is in practice to 92 terminals of 56 post offices.

International and domestic telegram services are available at 1,950 Telegraph Post Offices in the country. Among them, 1,100 Post Offices can offer the delivery services. Colombo Central Telegraph Office only serves 24 hours reception and others offer day-time service.

The past data for number of telegram in recent years are as follows:

Table 3-6 Number of Telegram Calls Handled

Year	Domestic	International	Total
1982	5,206,416	503,294	5,709,710
1983	3,008,496	459,334	3,467,830

There is no exclusive telegraph network in the country. TELEX exchange (NEDIX-510A) is used for the telegraph services as GENTEX by adding the stored and forward switching functions.

For telegraph service, terminal to terminal message exchange by paper tape is also in practice. In this case, telegraph terminal equipment is installed at telegraph handling offices. However, the telegraph network will be integrated by ISDN. Therefore, the demand for telegraph/telegram services is to be included in TELEX demand in this study.

3.2 Macroscopic Demand Forecast for TELEX and Telegram

Generally, TELEX subscribers increase rapidly before the service reaches a certain degree of diffusion. Then, as bothway communication type computer network (data communication network) develops, the number of TELEX subscribers who transfer to computer network increases, bringing TELEX subscriber growth to a stop or even causing the number of TELEX subscribers to decrease. This fact is proven by the situation in the countries where communication is developed.

While the telephone diffusion rate in the year 2000 still remains at a low level of 5.6 per population of 100, TELEX and telegraph service will be utilized in place of telephone service. Therefore, TELEX service demand is considered not to decrease in the future.

Assume that the penetration factor at the time the growth rate has reached the saturation point is 0.7 per population of 1,000, judging from the situation in the developed countries. when this number of TELEX subscribers is plotted on the logistic curve, the result obtained is as under.

$$Y = \frac{K}{1 + me^{-ax}}$$

where

Y: Number of TELEX subscribers X years after 1977 as initial year

K: Number of TELEX subscribers when the growth rate has reached the saturation point.

Assumption:
Growth saturation to take place in the year 2003
(estimated population: 20,000 x 10^3)

x: Number of years after 1977 as initial year

Consequently,

a = 0.2715
m = 86.630

Therefore,

K = 14,000

Accordingly, TELEX service demand can be estimated as under.

Table 3-7 TELEX Service Demand Forecast

Year	1984	1985	1990	1995	2000
Demand	1,100	1,642	4,768	9,344	12,410

As previously stated, 93% majority of TELEX subscribers is concentrated in Greater Colombo Area including Free Trade Zone. Therefore, even in the event the TELEX service at local post offices pulls up momentum, TELEX service concentration in Greater Colombo Area will remain unchanged. Thus, from the angle of demand, no need arises and will arise in the future to introduce the TELEX exchange other than Greater Colombo Area.

3.3 Demand Forecast for Public Pay Telephone Service

At present, in Greater Colombo Area, several outdoor type public pay telephones are installed. Private telephone service offices are also operating at several places.

Demand for public pay telephone service is to grow in proportion to ordinary telephone diffusion. Since public pay telephones are for use by indeterminate majority, theoretical forecast of demand size is difficult. This demand forecast should rather be identified as a policy line in National Communication Development Program to be implemented by the Government.

In this study, public pay telephone diffusion as under is recommended.

Table 3-8 Public Telephone Demand Forecast

Year	1985	1990	1995	2000
Penetration Rate per Population of 1,000	0.1	0.3	0.6	1.0
Number of Public Pay Telephones	1,590	5,130	10,920	19,300
Additional Installations	1,590	3,540	5,790	8,380

3.4 Demand Forecast for New Services

3.4.1 Classification of new services

In this study, new services are provisionally defined as services in general not provided by SLTD up to the present. Such new services include pocket bell paging, call waiting, telephone facsimile, call transfer and cellular mobile telephone which can be introduced by means of partial modification of or supplement to the existing telecommunication network, and high speed facsimile, data and video communications which can be realized by ISDN.

When telephone demand growth enters into the second half of expansion stage, convenience of telephony is all the more keenly recognized by the public. That is to say, telephone service is required to provide new services besides the mere call service. Out of new services, such kinds of services that contribute to the expansion

of SLTD's service menu and subserve to SLTD's diversified operation, and such kinds of services as call waiting and call transfer which are effective for improvement of call completion ratio should be positively introduced.

Here, new services are divided into two categories. One is the service category which SLTD is to provide to ordinary subscribers. The other is the service category wherein SLTD supplies circuits but terminal equipment is to be procured by users.

(1) Service category which SLTD is to provide to ordinary subscribers

Services that belong to this category are also classified into two sub-categories. They are:

A: Service that can be realized by partial modification of or supplement to the existing network.

B: Service to be realized by ISDN.

Service group that comes under (1)-A classification comprises call waiting, push-button dialling, abbreviated dialling, telephone facsimile and call transfer, etc.

Service group that comes under (1)-B classification comprises pocket bell paging and cellular mobile telephone, etc.

(2) Service category wherein SLTD supplies circuits but terminal equipment is to be procured by users according to the purpose of service

Services that belong to this category comprise high speed facsimile, data and video communications, etc.

3.4.2 Demand forecast for new services

For the aforementioned new services, no time series data whatsoever is available so that demand forecast is difficult. Furthermore, when new services are introduced, new tariff system for such services has to be established. And, depending upon how the tariffs are determined, demand itself varies a great deal in general.

For new services coming under (1)-A and (1)-B classifications each telephone exchange is to prepare positively related equipment, programs and so forth every time opportunity arises. For immediate future guideline, assumption is established that 10% out of the number of terminals installed be available for each new service.

As for service category (2), it is assumed that for all digital circuits including those for nationwide distribution of TELEX network as previously described, 10% spare circuits be available exclusively for providing of those services for the time being. Considering that in the year 2000 the circuits requirement for telephone service is to become large in scale, spare circuits to deal with calls beyond forecast must also be of correspondingly large capacity.

For new service circuits also, much greater capacity is expected to become necessary so that spare circuits equivalent to 20% of telephone service circuits are to be prepared.

Table 3-9 Spare Circuits Rate for New Services

Year	1985	1990	1995	2000
Spare Circuit Rate (%)	10	12	15	20

The commencement of operating the new services is to be studied by ascertainment of the demand trend for them through the detailed market research in the future.

4. DEMAND DISTRIBUTION

4.1 Telephone Demand Distribution

4.1.1 Distribution methodology

Result obtained by nationwide macroscopic demand forecast is to be distributed to each city, town and village for each forecast year. Method of distribution is to make proportional distribution to the existing demand (number of actual subscribers + number of waiting subscribers). That is to say,

$$Qi = Q \times \frac{Di}{\sum_{i=1}^{n} Di}$$

where

Q: Total demand in each forecast year, as forecasted in Section 2

Qi: Total demand in City i (Town i or Village i) in each forecast year

Di: Existing demand

Note: Di is based on data in "Exchange Review - 1983, SLTD Planning Division" published by SLTD.

$\sum_{i=1}^{n} Di$ in 1983 is 107,545. Out of this, 65,705 or upwards of 61% are concentrated in Greater Colombo Area. Result of demand distribution to each city, town and village by forecast year is in Table 3-10 and Volume II CHAPTER 2 in detail.

Table 3-10 (1/2) Summary of Demand Distribution (by SSC)

SSC Area		Existing (1983)			Distribution by Year			
No.	CODE	Working Sub.	Waiting Sub.	Total	1986	1990	1996	2000
1	ANR	917	359	1276	1808	3484	6582	12207
2	AMR	241	66	307	394	763	1442	2677
3	AVS	504	251	755	1069	2065	3896	7223
4	BDL	659	168	827	1172	2258	4267	7914
5	BTC	701	424	1125	1582	3063	5794	10754
6	BNR	809	216	1025	1446	2796	5285	9805
7	CNT	46468	19237	65705	100171	193914	366912	680902
8	CHW	364	164	528	747	1141	2724	5051
9	GLE	1673	987	2660	3748	7246	13705	25431
10	GMH	792	545	1337	1884	3644	6893	12787
11	HMB	281	184	465	658	1269	2398	4448
12	HTN	826	193	1019	1439	2779	5254	9748
13	JFN	2801	2519	5320	7495	14490	27409	50861
14	KLM	480	268	748	1053	2037	3853	7151
15	KND	4342	2536	6878	9686	18733	35433	65753

Table 3-10 (2/2) Summary of Demand Distribution (by SSC)

SSC Area		Existing (1983)			Distribution by Year			
No.	CODE	Working Sub.	Waiting Sub.	Total	1986	1990	1996	2000
16	KLT	1258	446	1704	2401	4644	8781	16291
17	KGL	525	189	714	1011	1948	3683	6830
18	KRG	1354	576	1930	2725	5266	9952	18459
19	MNR	218	110	328	467	899	1696	3140
20	MTL	771	334	1105	1559	3015	5700	10572
21	MTR	1335	517	1852	2618	5053	9550	17714
22	NWL	267	101	368	520	1003	1898	3520
23	NGM	1938	1879	3817	5370	10393	19960	36486
24	NWR	762	124	886	1251	2417	4567	8472
25	PLN	300	-	300	422	818	1546	2868
26	PND	968	410	1378	1941	3752	7099	13173
27	PTL	171	159	330	467	901	1702	3155
28	RTN	692	803	1495	2109	4076	7708	14297
29	TRN	673	89	763	1081	2082	3932	7291
30	VNY	341	246	587	831	1603	3028	5617

4.1.2 Demand distribution by exchange

Demand forecasted in the preceding paragraph is re-arranged by local exchange area. In this case, the exchange is either the existing exchange or the exchange under construction or being planned. Therefore, in case where Town A is presently covered by the exchange in City B, even if demand in Town A grows from now on and reaches the degree fit for establishing a new exchange, new exchange establishment is not considered, in principle, in the long term plan.

Result of demand distribution by exchange is in Volume II, CHAPTER 2.

4.2 TELEX, Telegram and Other Service Distribution

4.2.1 TELEX and telegram service

As previously stated, up to 93% of TELEX subscribers are concentrated in Greater Colombo Area and Trade Free Zone. This fact is considered not to change in the future either, because TELEX subscribers are mainly business corporations, shops and post offices. TELEX service distribution to other cities, towns and villages is taken up for consideration in same way as distribution of telephone demand.

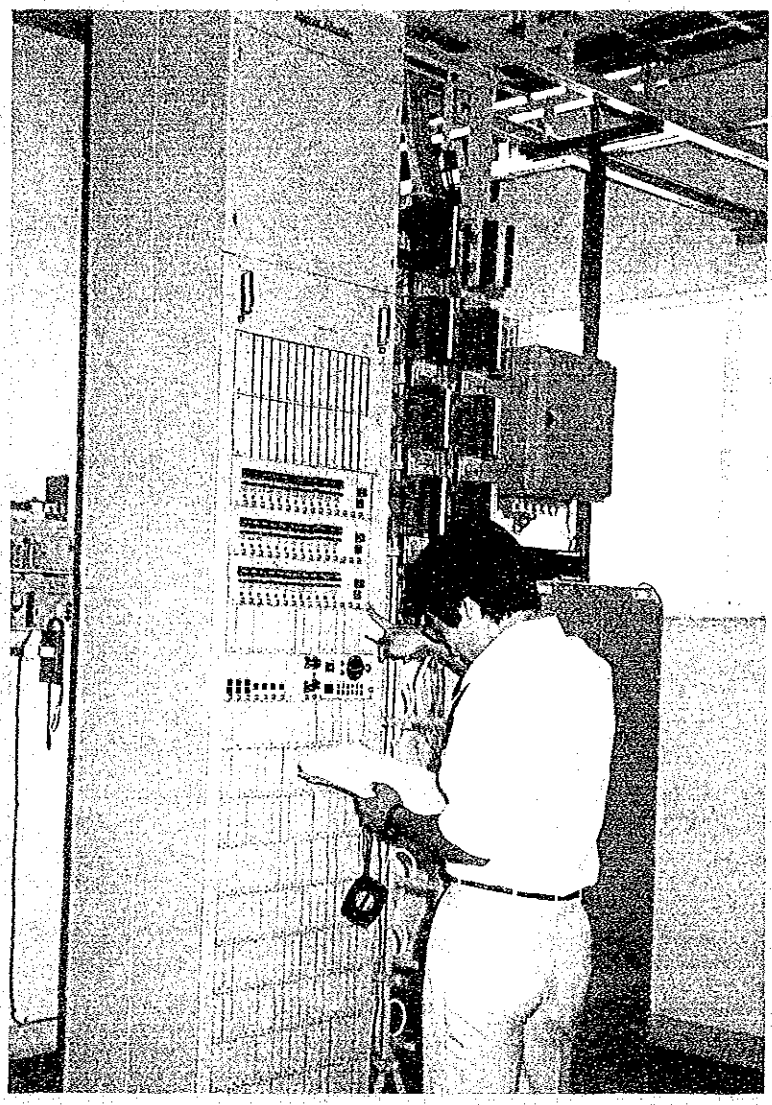
Table 3-11 Demand Distribution of TELEX

x	Year	Macro Demand	Colombo				Kandy TSC	Galle TSC	Anurad TSC	Total
			GCA	FTZ	Others	Sub Total				
7	1984	1100	967	56	25	81	34	13	5	52
8	1985	1642	1449	82	36	1567	49	18	8	75
13	1990	4768	4191	238	105	4534	157	53	24	234
18	1995	9344	8213	467	206	8886	308	103	47	458
23	2000	12410	10908	621	273	11802	410	136	62	608

4.2.2 Other services

For new services to be provided by the leased circuits, other than new services to be provided to general telephone subscribers, also demand sources will be almost completely in Greater Colombo Area as in the case of TELEX service. Hence no particular consideration of service distribution to other cities, towns and villages.

CHAPTER 4
TRAFFIC FORECAST AND CIRCUIT REQUIREMENTS



Panadura Exchange
Carrier Room

CHAPTER 4 TRAFFIC FORECAST AND CIRCUIT REQUIREMENTS

1. TRAFFIC FORECAST METHODOLOGY

1.1 Originating Calling Rate Estimate

Originating calling rate usually differs from exchange by exchange, depending upon the subscriber category and/or the number of subscribers according to the size of town, as well as the character of town. And it also varies broadly by hour, day and month, and season. Therefore, unless time series traffic data by considerably long term investigation is available, accurate originating calling rate estimate is impracticable.

In this long term plan, correlation between originating calling rate and number of subscribers of each exchange is obtained from traffic records of several exchanges measured by SLTD, and this correlation is assorted into patterns as under.

(1) Other area than Greater Colombo Area

No. of Subscribers	Originating Calling Rate (Erlang)
1 - 2,000	0.065
2,001 - 5,000	0.055
Over 5,001	0.045

(2) Greater Colombo Area

In Greater Colombo Area as multi-exchange area, originating call rate differs conspicuously according to the character of area where the exchange concerned is located, i.e., commercial area, administrative area, industrial area or residence area.

In this long term plan, originating calling rate is uniformly patterned at 0.08 Erlang regardless of the number of subscribers. This is based on the result of Mount Lavinia Exchange traffic measurement by SLTD.

Traffic measurement data, 1983/84, is in Table 4-1.

Table 4-1 Result of Traffic Measurement, 1983/1984

Exchange Code	Working Lines	Originating Traffic (Erl)	Originating Calling Rate (Erl./Sub)	Traffic Distribution	
				TO NSC	FROM NSC
AWR	576	23.7	0.041	13.11	12.11
AMR	214			6.39	5.36
AVS	186			5.75	2.0
BDL	380	17.4	0.046	8.5	13.56
BTC	639			10.0	12.7
BNR	360				
CHW	188	4.7		3.0	3.4
GLE	1160	75.0	0.064	38.9	23.7
GMH	512	31.7	0.06	22.1	
HMB	117			7.58	4.75
HTN	401	19.3	0.048	14.2	8.58
JFN	1829	84.8	0.046	54.8	24.67
KLM	345			8.11	5.78
KND	2317	101.8	0.044	63.0	53.25
KLT	601			19.3	16.4
KGL	311				
KRG	606	37.8	0.062	15.0	
MNR	137			4.33	2.61
MTL	549	19.3	0.035	13.1	8.08
MTR	768	54.4		22.25	17.42
NWL	191	9.36	0.049	7.2	4.94
NGM	1163	48.0		22.1	21.0
NWR	557			9.53	12.72
PLN	204	17.5		7.5	8.5
PND	707	28.17	0.04	14.6	5.0
PTL	134			3.7	2.7
RTN	318	14.6	0.046	9.9	9.25
TRN	512	22.7		12.74	12.58
VTN	211			4.74	6.31
CO-CEN				53.4	154.3
CO-E 10B				77.6	61.1
CO-MV	4950	392	0.079	37.0	46.0
ISC				14.97	147.0

1.2 Toll Call Ratio Estimate

Toll call ratio grows steadily as nationwide SLTD network improves. However, as the number of subscribers in local call area increases and as the area expands, local calls are to increase and toll call ratio lowers.

Result of toll call ratio measurement is in Table 4-2.

Table 4-2 Toll Call Ratio Measurement (1983/84)

Exchange	ANR	BDL	CNW	GLE	GMH	HTN	JFN	KND	KRG
Toll Call Ratio	55	49	64	52	69.7	73.5	64.6	62	40

Exchange	MTL	MTR	NWL	NGM	PLN	PND	RTN	TRN	CNT
Toll Call Ratio	67.5	41	77	46	43	52	68	56	10.3

From Table 4-2 above, it can be known that in Greater Colombo Area, the number of local calls is much greater than that number of toll calls; hence lower toll calling rate than in local cities. Thus, in this long term plan, twofold toll calling rate patterns are used, one for Greater Colombo Area and the other for local cities. That is to say,

(1) Greater Colombo Area 15%
(2) Local cities 70%

In local cities (single exchange areas), local calls (Intraoffice calls) account for 30%, i.e., the balance after excluding toll calls. In Greater Colombo Area, local calls comprise ordinary intraoffice calls and local junction calls. Therefore, on the assumption that the sum of local junction calls and toll calls accounts for 70%, junction circuit requirements are calculated in the Master Plan.

2. LOCAL EXCHANGE TRAFFIC FORECAST

Subscriber side traffic at local exchange (LE) can be obtained as under.

$$A_S = (C_{ORG} + C_{TER}) \times T$$

where

A_S: total originating/terminating traffic on subscriber side

C_{ORG}: Originating calling rate

C_{TER}: Terminating calling rate. Here, to be equal to C_{ORG}

T: Number of subscribers

Trunk side traffic at local exchange is obtained by

$$A_T = A_S \times P$$

where

A_T: Trunk side traffic

P: Toll calling rate

A_T value at each local exchange is in Volume II CHAPTER 3.

3. SECONDARY CENTER AND TERTIARY CENTER TRAFFIC FORECAST

Trunk side traffic (A_T) at local exchanges obtained in the preceding paragraph 2 are to be collected at own secondary center and then to be exchanged on undermentioned routes.

(1) To local exchange in the same secondary center area

(2) To other area via own tertiary center (by final route)

(3) To international route (fully provided route) via national center of Colombo

Exchange by exchange traffic records classified by the foregoing routes are not available. Therefore, in this long term plan, secondary and tertiary center traffic is estimated, based on "SLTD National Network Plan, Drawing No. TP-2209, dated April 9, 1984" prepared by SLTD (Fig. 4-1).

Traffic forecasts for years 1990, 1995 and 2000 are made by

$$A_x = A_{1985} \times \text{(traffic increment rate as of year x in secondary center area, compared with 1985)}$$

Year by year traffic increment rate in secondary center area, compared with 1985, is in Table 4-3.

Traffic volume and circuit requirements between secondary center (hereafter abbreviated as SSC) and tertiary center (hereafter abbreviated as TSC) for each forecast year are in Table 4-4.

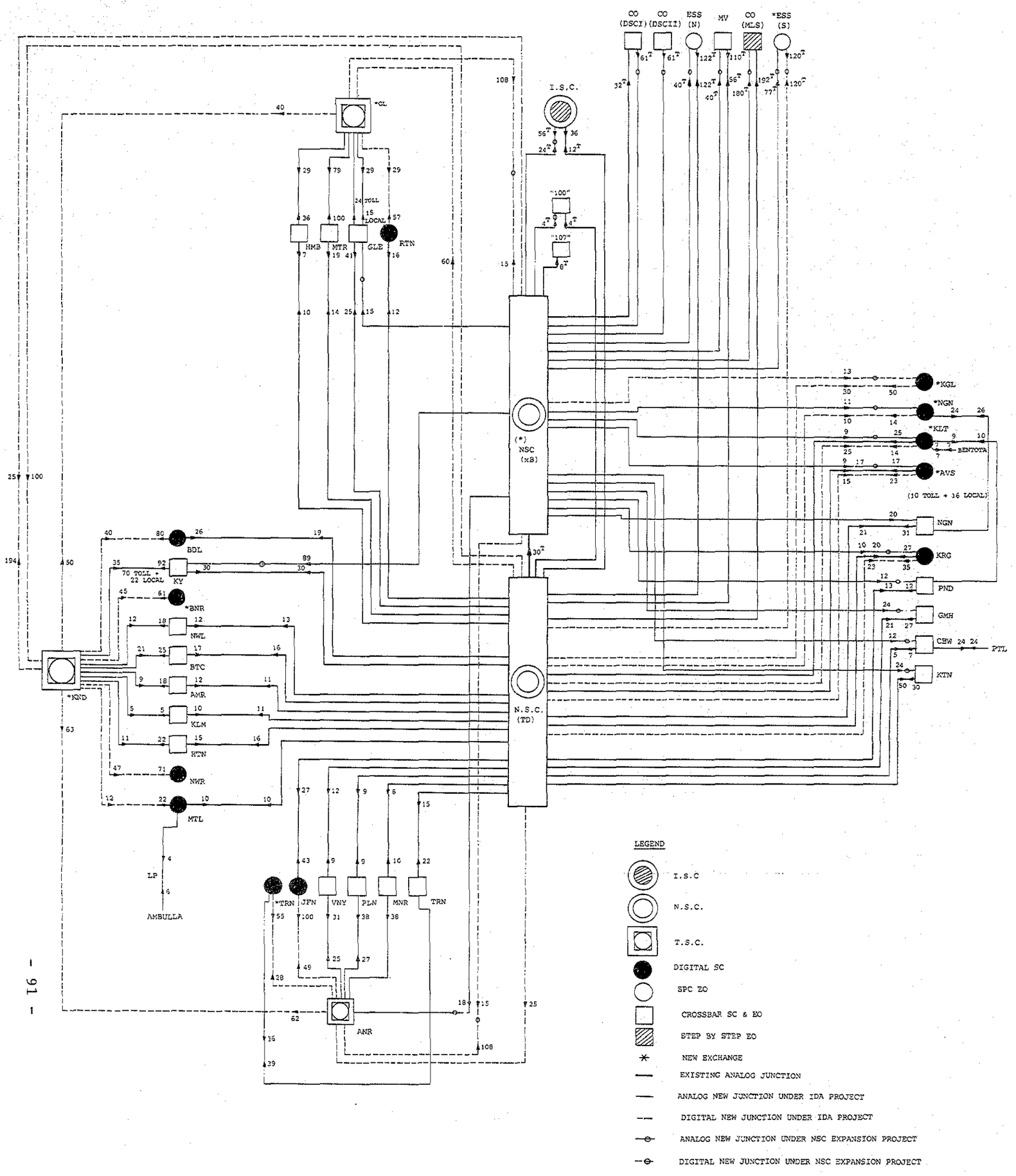


Figure 4-1 Sri Lanka National Network Plan 1985

Traffic forecast between TSC's is by the same method as above. Traffic volume and circuits required, given in the aforementioned SLTD National Network Plan, are used as forecasted requirements for 1985 (after IDA Project termination).

At present, between Galle TSC and Anuradapura TSC, no direct traffic is expected. However, in the future, more or less traffic, mainly of administrative communication, is considered to arise.

Traffic increment rate between TSC's compared with 1985 is obtained by means of comparison of the sum of outgoing and incoming traffics of all SSC's in each TSC area with 1985 equivalent. Calculation result is in Table 4-5.

Table 4-3 SSC-Traffic Growth Ratio

SSC Code	Traffic Growth Ratio			
	1985	1900	1995	2000
CNT- KTN	1.00	1.64	3.10	4.71
CHW	1.00	1.93	3.64	6.76
KRG	1.00	1.77	3.06	5.67
KGL	1.00	1.93	3.64	6.25
GMH	1.00	1.74	3.30	5.28
AVS	1.00	1.93	3.64	6.41
KLT	1.00	1.79	3.20	4.94
PND	1.00	1.69	2.75	4.90
NGN	1.00	1.65	3.13	5.46
CNT	1.00	1.90	3.51	6.32
PTL	1.00	1.93	3.66	6.00
KND- MTL	1.00	1.69	3.26	5.32
BTC	1.00	1.68	3.18	5.01
KLM	1.00	1.94	3.25	5.27
AMR	1.00	1.94	3.66	5.76
BDL	1.00	1.93	3.32	5.55
BNR	1.00	1.92	3.31	5.48
NWR	1.00	1.93	3.29	5.44
HTN	1.00	1.93	3.31	6.15
NWL	1.00	1.92	3.64	5.88
KND	1.00	1.89	3.45	6.00
GLE- RTN	1.00	1.77	3.34	5.42
HMB	1.00	1.93	3.63	6.74
MTR	1.00	1.74	2.93	5.44
GLE	1.00	1.69	3.11	5.77
ANR- MNR	1.00	1.93	3.62	6.10
JFN	1.00	1.93	3.60	6.62
VNY	1.00	1.93	3.64	6.68
TRN	1.00	1.93	3.24	5.63
PLN	1.00	1.94	3.66	6.80
ANR	1.00	1.73	3.27	5.38

Table 4-4 (1/2) SSC Estimated Traffic and No. of Circuits Required

SSC NAME		ESTIMATED TRAFFIC (IN ERLANG)								NUMBER OF CIRCUITS REQUIRED							
		1985		1990		1995		2000		1985		1990		1995		2000	
TSC	CODE	OUT	IN	OUT	IN	OUT	IN	OUT	IN	OUT	IN	OUT	IN	OUT	IN	OUT	IN
CNT	KTN	35.1	66.6	57.8	109.2	108.8	206.5	165.3	313.7	39	74	72	127	127	230	186	349
	CHV	6.3	10.8	12.2	20.8	22.9	39.3	42.6	73.0	7	17	21	31	33	52	56	89
	KRG	55.8	52.2	98.8	92.4	170.7	159.7	316.4	296.0	62	53	116	109	190	180	352	329
	KGL	45.0	38.7	86.9	74.7	163.8	140.9	281.3	241.9	50	43	104	91	184	160	313	269
	GMH	24.3	40.5	42.3	70.5	80.2	133.7	128.3	213.8	27	45	55	95	96	153	147	238
	AVS	27.0	36.9	52.1	71.2	98.3	134.3	173.1	236.5	40	41	66	87	116	153	194	263
	KLT	49.5	45.9	88.6	82.2	158.4	146.9	244.5	226.7	55	51	105	99	176	166	272	252
	PND	19.8	30.6	33.5	51.7	54.5	84.2	97.0	149.9	22	34	46	66	69	101	114	170
	NGN	40.5	55.8	66.8	92.1	126.8	174.7	221.1	304.7	45	62	82	109	145	195	246	339
	CNT	426.6	663.3	810.5	1260.3	1497.4	2328.2	2696.7	4192.0	474	859	900	1400	1664	2587	2997	4658
	PTL	21.2	21.2	40.9	40.9	77.6	77.6	127.2	127.2	24	24	54	54	94	94	146	146
		(751.1)	(1062.5)	(1390.2)	(1966.0)	(2559.4)	(3626.0)	(4493.5)	(6375.4)								
XND	MTL	32.4 (9.0)	25.2 (9.0)	70.0	57.8	135.0	111.5	220.2	181.9	46	38	85	72	154	129	245	203
	BTC	37.8 (15.3)	33.3 (14.4)	89.2	80.1	168.9	151.7	266.0	239.0	59	53	106	96	189	171	296	266
	XLM	13.5 (9.0)	14.4 (9.9)	43.7	47.1	73.1	79.0	118.6	128.1	25	27	57	61	89	95	137	147
	AMR	27.0 (10.8)	18.0 (9.9)	73.3	54.1	138.3	102.1	217.7	160.7	42	31	89	68	158	120	243	181
	BDL	95.4 (24.4)	53.1 (17.1)	229.3	135.5	394.4	233.1	659.3	389.6	132	78	255	155	439	259	733	432
	BNR	54.9 (-)	40.5 (-)	105.4	77.8	181.7	134.1	300.9	221.9	61	45	123	94	202	149	334	246
	KNO	63.9 (-)	42.3 (-)	123.3	81.6	210.2	139.2	350.2	231.8	71	47	142	98	234	155	389	258
	HTN	33.3 (13.5)	24.3 (14.4)	90.3	74.7	154.9	128.1	254.6	210.5	52	43	107	91	175	147	283	234
	NWL	27.0 (10.8)	22.5 (11.7)	72.6	65.7	137.6	124.5	222.3	201.1	42	38	88	81	157	143	247	224
	NWR	109.8 (27.0)	138.6 (107.1)	258.6	464.4	472.0	847.7	820.8	1474.2	152	273	288	516	525	942	912	1638
		(613.8)	(805.7)	(1155.7)	(1138.8)	(2066.1)	(2051.0)	(3430.6)	(3438.8)								

Table 4-4 (2/2) SSC Estimated Traffic and No. of Circuits Required

SSC NAME		ESTIMATED TRAFFIC (IN ERLANG)								NUMBER OF CIRCUITS REQUIRED							
		1985		1990		1995		2000		1985		1990		1995		2000	
TSC	CODE	OUT	IN	OUT	IN	OUT	IN	OUT	IN	OUT	IN	OUT	IN	OUT	IN	OUT	IN
GLE	RTN	65.7 (14.4)	36.9 (10.8)	141.8	84.4	267.5	159.3	434.1	258.5	89	48	161	101	298	179	483	288
	HMB	38.7 (6.3)	35.1 (9.0)	86.9	85.1	163.4	160.1	303.3	297.2	50	49	114	102	184	180	337	331
	MTR	107.1 (17.1)	83.7 (12.6)	216.1	167.6	363.9	282.2	675.6	523.9	138	107	240	188	405	314	751	583
	GLE	72.0 (36.9)	62.1 (36.0)	184.0	165.8	338.7	305.1	628.4	566.0	121	109	205	184	377	339	699	629
		(358.2)	(286.2)	(618.8)	(502.9)	(1133.5)	(906.7)	(2041.4)	(1645.6)								
AHR	HNR	43.2 (9.0)	35.4 (5.4)	88.2	69.0	189.0	136.3	318.4	248.9	58	46	105	84	210	155	354	277
	JFK	128.7 (38.7)	68.4 (24.3)	323.1	178.9	607.7	336.5	1108.2	613.7	186	103	359	199	676	374	1232	682
	VNY	36.0 (8.1)	33.3 (10.8)	85.1	85.1	129.2	137.1	294.6	294.6	49	49	102	102	148	156	328	328
	TRM	69.3 (19.8)	38.7 (13.5)	172.0	100.7	277.1	162.3	501.6	293.9	99	58	192	118	308	182	558	327
	PLM	42.3 (8.1)	32.4 (8.1)	97.8	78.6	184.5	148.2	342.7	275.4	56	45	115	95	205	168	381	306
	ANR	74.9 (-)	74.9 (-)	129.6	129.6	244.9	244.9	403.0	403.0	84	84	148	148	273	273	448	448
		(478.1)	(345.2)	(895.8)	(641.9)	(1632.4)	(1165.3)	(2968.5)	(2129.5)								

* NOTE: No. of Circuits includes th are circuits for TEX or New Services.

Table 4-5 Traffic Increment Rate Between TSC's

TSC \ Year	1986	1990	1996	2000
Colombo TSC	1.00	1.85	3.41	5.98
Galle TSC	1.00	1.73	3.16	5.70
Kandy TSC	1.00	1.88	3.37	5.59
Anuradapura TSC	1.00	1.87	3.41	6.21

For Colombo TSC - Galle TSC traffic, for instance, the increment ratios of each TSC differ considerably so that the mean value obtained by the method of least square is adopted.

Inter-TSC traffic forecast thus obtained is in Table 4-6.

Table 4-6 (1/4) Inter-TSC Traffic Forecast (1985)

Table 4-6 (2/4) Inter-TSC Traffic Forecast (1990)

Table 4-6 (3/4) Inter-TSC Traffic Forecast (1995)

Table 4-6 (4/4) Inter-TSC Traffic Forecast (2000)

Table 4-6 (1/4) Inter-TSC Traffic (1985)

From \ To	Colombo	Galle	Kandy	Anuradapura
Colombo	-	67.5	112.5	52.2
Galle	118.8	-	36.0	-
Kandy	174.6	45.0	-	56.7
Anuradapura	97.2	-	55.8	-

Table 4-6 (2/4) Inter-TSC Traffic (1990)

From \ To	Colombo	Galle	Kandy	Anuradapura
Colombo	-	120.9	209.8	97.1
Galle	212.8	-	65.0	-
Kandy	325.6	81.3	-	106.3
Anuradapura	180.8	-	104.6	-

Table 4-6 (3/4) Inter-TSC Traffic (1995)

From \ To	Colombo	Galle	Kandy	Anuradapura
Colombo	-	221.9	381.4	178.0
Galle	351.4	-	117.6	39.1
Kandy	591.9	147.0	-	192.2
Anuradapura	298.4	31.9	189.2	-

Table 4-6 (4/4) Inter-TSC Traffic (2000)

From \ To	Colombo	Galle	Kandy	Anuradapura
Colombo	-	394.3	651.2	318.2
Galle	624.5	-	203.2	70.9
Kandy	1010.6	254.0	-	335.0
Anuradapura	533.4	57.8	330.0	-

4. CIRCUIT REQUIREMENTS

For circuit requirements, calculation is made, based on forecasted traffic volume for each forecast year as per the preceding paragraph and using Erlang-B formula at the call loss rate (1/100) described in CHAPTER 5.

(1) Primary center - secondary center circuit requirement: See Volume II CHAPTER 3.

(2) Secondary center - tertiary center circuit requirement: See Table 4-4.

(3) Tertiary center - tertiary center circuit requirement: See Table 4-7.

Foregoing are the point to point circuit requirements. When installation plan is formulated, there is need for overlaying the necessary number of circuits for each transmission route.

Table 4-7 (1/4) Circuits Required between TSC's (1985)

Table 4-7 (2/4) Circuits Required between TSC's (1990)

Table 4-7 (3/4) Circuits Required between TSC's (1995)

Table 4-7 (4/4) Circuits Required between TSC's (2000)

Table 4-7 (1/4) Circuits Required Between TSC's (1985)

From \ To	Colombo	Galle	Kandy	Anuradapura
Colombo	-	75	125	58
Galle	132	-	40	-
Kandy	194	50	-	63
Anuradapura	108	-	62	-

Table 4-7 (2/4) Circuits Required Between TSC's (1990)

From \ To	Colombo	Galle	Kandy	Anuradapura
Colombo	-	139	234	114
Galle	237	-	80	-
Kandy	362	98	-	124
Anuradapura	201	-	122	-

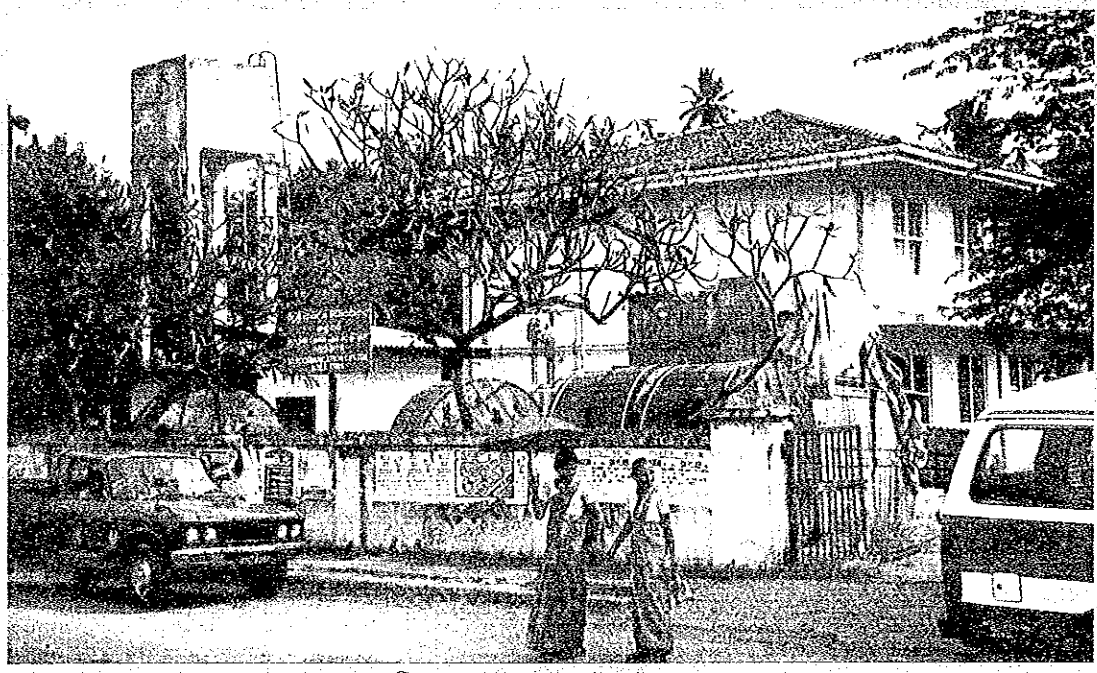
Table 4-7 (3/4) Circuits Required Between TSC's (1995)

From \ To	Colombo	Galle	Kandy	Anuradapura
Colombo	-	247	424	199
Galle	391	-	136	52
Kandy	658	167	-	214
Anuradapura	332	44	211	-

Table 4-7 (4/4) Circuits Required Between TSC's (2000)

From \ To	Colombo	Galle	Kandy	Anuradapura
Colombo	-	439	724	354
Galle	694	-	226	86
Kandy	1123	283	-	373
Anuradapura	593	72	367	-

CHAPTER 5
NETWORK FUNDAMENTAL PLAN



Scene in front of Kalutara
Exchange

CHAPTER 5 NETWORK FUNDAMENTAL PLAN

1. NATIONAL NUMBERING PLAN

1.1 Existing National Numbering Plan

National numbers in Sri Lanka are composed of trunk prefix "0" + toll exchange code + directory number (exchange number + subscriber number). In Colombo and several other multi-exchange areas, local calls require directory number dialling; however, in almost all other cities, subscriber numbers only are dialled for local calls.

The closed numbering scheme is planned in the Secondary Switching Center (SSC) area. According to this plan, calls to exchanges in the same SSC area do not require toll exchange code dialling. That is to say, directory number (exchange number + subscriber number) only is dialled. Special service numbers, though not standardized through the country at present, are to be standardized at three digits of "1XY" in the future. International STD calls are discriminated by international prefix "00".

For directory numbers in Colombo Tertiary Switching Center (TSC) area, both five-digit number and six-digit numbers are used whereas in local cities, four-digit numbers and five-digit numbers are mixed. Tables 5-1 and 5-2 present the existing national numbering plan in Sri Lanka. This numbering plan should be modified at an early opportunity because telephone demand has been broadly increased as a result of demand reassessment and also because the local exchange accommodation to toll exchange plan has been changed by IDA project and related projects.

1.2 Numbering Plan Modification

Numbering plan modification entrails much troubles on the competent authority, such as, exchange data program alteration for electronic switching equipment and subscriber familiarization with new numbering plan as well as plant record corrections of many kinds. Subscribers also cannot but be greatly inconvenienced before they become accustomed to the handling of new numbers.

For the establishment of new numbering plan, utmost care has to be exercised on the following points:

(1) To make number allocations with sufficient room for satisfying new needs so that another numbering modification will not be necessary for a long time.

(2) To so arrange that by the first digit or by the first and second digits the area discrimination is possible.

(3) To reserve spare numbers for new services, such as mobile telephone and pocket bell services.

Table 4-3 introduces new numbering plan wherein the foregoing requirements are duly considered. This new numbering plan can cater for demand up to the year 2000 and even beyond.

The new numbering plan is to be put into practice as the case may be when new/additional switching equipment installation project is implemented. Especially in Colombo Area, the existing directory numbers are assigned by numbers in their hundredths for each exchange, the existing numbering plan should be gradually modified and rearranged.

1.3 Special Service Numbers

At present, special service numbers are not standardized throughout the country. They will be standardized at three digits of "1XY" in due course.

Now, in the Municipality of Colombo, emergency numbering (police, fire brigade and ambulance) consists of 22222 and 33333. This is to prevent misdialling. However, these days, dialling accuracy has been improved so that misdialling probability has been reduced. Thus, for emergency numbering also, three digit combination of "1XY" is to be used.

Table 5-2 presents the existing emergency and special service numbering.

1.4 TELEX Numbering Plan

As stated in CHAPTER 3, more than 93% of TELEX subscribers are concentrated in the Greater Colombo Area at present. Hence no national numbering plan worth the name. This trend of TELEX subscriber concentration in the Greater Colombo Area is considered to continue so that the existing five-digit numbering plan (2XXXX) does not need to be modified at least until 1995.

However, after 1995, as demand of TELEX exceeds 10,000 in the number of subscribers, the new numbering 3XXXX has to be additionally considered.

1.5 New Service Numbering Plan

Idle number of "10X" is to be utilized. Actual numbering plan consists of "10X" ("102", "103", "104", "105", "106", "107", "108", "109") + new service subscriber number. In the case of mobile telephone service, for example, the number is composed of "105" + XXXX, where XXXX is an exclusive mobile telephone number separate from telephone service number.

Table 5-1 Sri Lanka National Numbering Plan (1/6)

(A) Colombo T.S.C. Area	Code		Directory Number
Colombo	01	Colombo I.S.C.	
		Colombo Central	2 XXXX
		Colombo City	32 XXXX to 34 XXXX
		Colombo East	48 XXXX to 49 XXXX
		Colombo North	51 XXXX to 54 XXXX
		Colombo South	55 XXXX to 50 XXXX
		Maradana	9 XXXX
		Mt. Lavinia	71 XXXX to 72 XXXX
Katunayaka	030		2 XXX to 3 XXX
Negombo	031	Negombo	2 XXX to 4 XXX
		Lunuwila	5 XXX
		Dunagaha	6 XXX
		Kochchikade	7 XXX
		Badalgama	81 XX to 85 XX
		Sadalankawa	86 XX to 89 XX
Chillaw	032	Chillaw	2 XXX to 4 XXX
		Puttalan	5 XXX to 7 XXX
		Karawil	8 XXX
Gampaha	033	Gampaha	2 XXX to 4 XXX
		Veyangoda	5 XXX
		Veliveriya	6 XXX
		Mirigama	7 XXX

Table 5-1 Sri Lanka National Numbering Plan (2/6)

(A) Colombo T.S.C. Area	Code		Directory Number
Kalutara	034	Kalutara	2 XXXX to 3 XXX
		Panadura	4 XXXX
		Horana	51 XXX
		Bandaragama	52 XXX
		Ingiriya	53 XXX
		Bentota	6 XXXX
		Matugama	71 XXX
		Neboda	72 XXX
		Meegahatenna	74 XXX
Kegalle	035	Kegalle	2 XXX to 4 XXX
		Rambakkana	5 XXX
		Mawanella	6 XXX
		Warakapola	7 XXX
		Aranayake	81 XX to 85 XX
		Undogoda	86 XX to 89 XX
		Kotiyakumbura	91 XX to 95 XX
		Galapitamada	96 XX to 99 XX
Avissawella	036	Avissawella	2 XXX to 4 XXX
		Kosgama	5 XXX
		Bulathkohupitiya	6 XXX
		Kitulgala	7 XXX
		Eneliyagoda	8 XXX
		Deraniyagala	91 XX to 95 XX
		Yatiyantota	96 XX to 90 XX
Kurunegala	037	Kurunegala	2 XXXX to 3 XXXX
		Kuliyapitiya	41 XXX to 42 XXX
		Polgahawela	43 XXX to 44 XXX
		Maho	45 XXX
		Pannala	46 XXX
		Wariyapola	47 XXX
		Giriulla	48 XXX
		Narammala	49 XXX
		Nikaweratiya	50 XXX
		Hettipola	51 XXX
		Ridigama	52 XXX
		Galagamuwa	53 XXX
		Nikadalupotha	54 XXX

Table 5-1 Sri Lanka National Numbering Plan (3/6)

(B) Kandy T.S.C. Area	Code		Directory Number
Kandy	08	Kandy	2 XXXX to 4 XXXX
		Peradeniya	8 XXXX
		Katugastota	9 XXXX
		Gampola	5 XXXX
		Galagedera	61 XXX
		Madulkele	63 XXX
		Rikilagaskada	65 XXX
		Galaha	67 XXX
		Kadugannawa	71 XXX
		Digana	74 XXX
		Wattegama	76 XXX
		Pussellawa	78 XXX
Hatton	051	Hatton	2 XXX to 3 XXX
		Talawakelle	5 XXX
		Punduluoya	6 XXX
		Ginigathena	7 XXX
Nuwara Eliya	052	Nuwara Eliya	2 XXX to 4 XXX
		Halgranoya	5 XXX
		Maturata	6 XXX
		Ramboda	7 XXX
		Udapussellawa	8 XXX
		Watumulla	9 XXX
Nawalapitiya	054	Nawalapitiya	2 XXX to 3 XXX
		Kotmale	5 XXX
		Dolosbage	6 XXX
Badulla	055	Badulla	2 XXX to 3 XXX
		Moneragala	40 XX to 41 XX
		Mahiyangana	42 XX to 43 XX
		Passara	44 XX to 45 XX
		Padiyatalawa	46 XX to 47 XX
		Wellawaya	48 XX to 49 XX
		Namunukula	50 XX to 51 XX
		Haliela	52 XX to 53 XX
		Bibile	54 XX to 55 XX
		Kandaketiya	56 XX to 57 XX
		Madulsima	58 XX to 59 XX

Table 5-1 Sri Lanka National Numbering Plan (4/6)

(B) Kandy T.S.C. Area	Code	Directory Number
Bandarawela	057 Bandarawela	2 XXX to 4 XXX
	Welimada	5 XXX
	Ella	6 XXX
	Ampitikanda	7 XXX
	Haputale	8 XXX
Ampara	063 Ampara	2 XXX
	Kalmunai	4 XXX
	Akkaraipattu	7 XXX
Batticaloa	065 Batticaloa	2 XXX to 3 XXX
	Valachchenai	7 XXX
Matale	066 Matale	2 XXX to 4 XXX
	Weligamuwa	5 XXX
	Naula	61 XX to 65 XX
	Elahera	66 XX to 60 XX
	Mahawela	71 XX to 75 XX
	Dambulla	8 XXX

(C) Anuradhapura T.S.C. Area	Code	Directory Number
Jaffna	021 Jaffna	2 XXXX to 3 XXXX
	Karaveddy	4 XXXX
	Telippalai	5 XXXX
	Sitankerni	6 XXXX
	Kayts	7 XXXX
	Kilinochchi	8 XXXX
	Chavakachcheri	91 XXX
	Pallai	92 XXX
	Pooneryn	93 XXX
	Delft	94 XXX
	Pungudutivu	95 XXX
Mannar	023 Mannar	2 XXX
	Murunkan	4 XXX
	Madhu	5 XXX
	Talaimannar	6 XXX

Table 5-1 Sri Lanka National Numbering Plan (5/6)

(C) Anuradhapura T.S.C. Area	Code		Directory Number
Vavuniya	024	Vavuniy	2 XXX to 3 XXX
		Mankulam	5 XXX
		Mullaitivu	6 XXX
		Padaviya	7 XXX
Anuradapura	025	Anuradapura	2 XXX to 3 XXX
		Keikirawa	40 XX to 49 XX
			50 XX to 55 XX
		Medawachchiya	56 XX to 59 XX
			60 XX to 61 XX
		Tambuttegama	62 XX to 69 XX
			70 XX to 73 XX
		Kahatagasdigiliya	74 XX to 77 XX
		Nochchiyagama	78 XX to 79 XX
			80 XX to 81 XX
		Galenbindunuwewa	82 XX to 83 XX
		Horowpothana	84 XX to 85 XX
		Kebitigollewa	86 XX to 87 XX
Trincomalee	026	Trincomalee	2 XXX to 4 XXX
		Chinabay	5 XXX
		Kantalai	61 XX to 65 XX
		Kiliveddi	66 XX to 69 XX
		Kuchchaveli	70 XX to 74 XX
		Nilaveli	75 XX to 79 XX
		Toppur	80 XX to 81 XX
		Tampalakaman	85 XX to 89 XX
		Morawewa	90 XX to 82 XX
		Pulmudai	93 XX to 95 XX
		Mutur	96 XX to 98 XX

Table 5-1 Sri Lanka National Numbering Plan (6/6)

(D) Galle T.S.C. Area	Code		Directory Number
Polonnaruwa	027	Polonnaruwa	2 XXX to 3 XXX
		Hingurakgoda	5 XXX
Galle	09	Galle	2 XXXX to 3 XXXX
		Elpitiya	51 XXX
		Baddegama	52 XXX
		Habaraduwa	53 XXX
		Kosgoda	54 XXX
		Udugama	55 XXX
		Imaduwa	56 XXX
		Talgaswela	57 XXX
		Ambalangoda	8 XXX
Matara	041	Matara	2 XXX to 4 XXX
		Weligama	5 XXX
		Deniyaya	6 XXX
		Kamburupitiya	7 XXX
		Akuressa	8 XXX
Ratnapura	045	Ratnapura	2 XXX to 3 XXX
		Pelmadulla	4 XXX
		Kalawana	50 XX to 57 XX
		Kiriella	58 XX to 59 XX
		Rakwana	60 XX to 67 XX
		Kolonne	68 XX to 69 XX
		Balangoda	70 XX to 77 XX
		Timbolketiya	78 XX to 79 XX
		Embilipitiya	80 XX to 84 XX
		Bambarabotuwa	85 XX to 89 XX
		Nivitigala	90 XX to 94 XX
Hambantota	047	Hambantota	2 XXX
		Tissamaharama	3 XXX
		Kataragama	40 XX to 44 XX
		Tanamalwila	45 XX to 49 XX
		Ambalantota	5 XXX
		Tangalle	6 XXX
		Walasmulla	70 to 74 XX
		Weeraketiya	75 to 79 XX
		Angunakolapelessa	80 to 84 XX

Table 5-2 Emergency and Special Service Numbering

Service	Code
Assistance and trunk booking	101
Emergency	125 *1
Priority trunk booking	120
Indian trunk booking	130
Directory Enquiries - Sinhala	136
Directory Enquiries - Tamil	137
Directory Enquiries - English	138
Enquiries - Sinhala	141
Enquiries - Tamil	151
Enquiries - English	161
Phonogram - Sinhala	131
Phonogram - Tamil	132
Phonogram - English	133
Telephone - Telegram	181
Time - Sinhala	102
Time - Tamil	103
Time - English	104
Complaints	121 *2
Testing by Faultsman	191
Faultsman's Ringback	129
Foreign Booking by SSC Operator	110
Overseas Trunk Booking	100

*1: In Colombo area, 22222 for Police and 33333 for Fire and Ambulance

*2: In Colombo area, 121 for Central SXS, 122 for Havelock Town SXS, 123 for Maradana SXS and 124 for other all exchanges.

Table 5-3 (A) (1/10) New Numbering Plan Proposed

TSC	SSC	LE	DIRECT NO. (PROPOSED)	CAPACITY in 2000x1.5	DEMAND
CNT	CNT (01)	CO-Central	2XXX		Demand in 2000x1.5 680902x1.5=1021353
		CO-city	32XXXX - 34XXXX		
		CO-East	48XXXX - 49XXXX		
		CO-North	51XXXX - 54XXXX		Refer to Table
		CO-South	55XXXX - 50XXXX		
		Maradana	9XXXX		
		Mt. Lavinia	71XXXX - 72XXXX		
	KTN (030)	Katunayaka	2XXXX - 3XXXX	20000	Demand in 2000x1.5 8440x1.5=12660
	NGM (031)	Negombo	2XXXX - 4XXXX 9XXXX	40000	22921x1.5=34382
		Lunwila	55XXX - 58XXX	4000	2189x1.5=3284
		Dunagaha	66XXX - 68XXX	3000	1587x1.5=2381
		Kochchikade	77XXX - 78XXX	2000	765x1.5=1148
		Badalgama	81XX - 85XX 80XX	600	383x1.5=575
		Samdalankawa	86XX - 89XX	400	201x1.5=302
	CHW (032)	Chillaw Bingiriya Madampe Mundel Rajakadaluwa	22XXX - 29XXX	8000	1922x1.5=2883 220x1.5=330 851x1.5=1277 241x1.5=362 259x1.5=389 — 5241
		Marawila	87XXX - 89XXX	3000	1558x1.5=2337
		Puttalam Anamaduwa Kalpitiya Madurankuli Mampuri	52XXX - 59XXX	8000	2361x1.5=3542 306x1.5=459 287x1.5=431 153x1.5=230 48x1.5=72 — 4734
	GMH (033)	Gampaha Urapola Ganemulla Kalagedihena	2XXXX - 3XXXX	20000	8136x1.5=12204
		Veyangoda	52XXX - 57XXX	6000	2113x1.5=3170
		Pallewela			115x1.5=173
		Pasyala Kaleliya			374x1.5=561 — 3904

Table 5-3 (A) (2/10) New Numbering Plan Proposed

TSC	SSC	LE	DIRECT NO. (PROPOSED)	CAPACITY in 2000x1.5	DEMAND
CNT	GMH (033)	Veliveriya Kirindiwila	66XXX - 67XXX	2000	929x1.5=1394
		Mirigama Kotadeniyawa	77XXX - 78XXX	2000	1120x1.5=1680
	KLT (034)	Kalutara	2XXXX - 3XXXX	20000	7752x1.5=11628
		Bentota	6XXXX	10000	5649x1.5=8474
		Matugama Agalawatta Latpandura Welipanna	71XXX.73XXX 75XXX.76XXX	4000	2019x1.5=3029
		Migahatenna	74XXX	1000	239x1.5=359
		Neboda Tebuwana	72XXX	1000	335x1.5=503
		Bulatlsinghala Mahagama	77XXX	1000	297x1.5=446
		Panadura	4XXXX.8XXXX	20000	10008x1.5=15012
		Bandaragama	52XXX	1000	660x1.5=990
		Horana Govinna	51XXX. 54XXX - 56XXX	4000	2151x1.5=3227
		Ingiriya	53XXX	1000	354x1.5=531
	KGL (035)	Kegalle Ambanpitiya	22XXX - 27XXX	6000	3671x1.5=5507
		Rambukkana	5XXX	1000	612x1.5=918
		Mawanella Hemmatagama	66XXX - 67XXX	2000	1292x1.5=1938
		Warakapola	77XXX - 78XXX	2000	1100x1.5=1650
		Nelundeniya			96x1.5=144
		Galopitamada	96XX - 99XX	400	39x1.5=59
		Aranayake	81XX - 85XX	500	287x1.5=431
		Undugoda	86XX - 89XX	400	144x1.5=216
		Kotiyakumbura Tuntota	91XX - 95XX	500	201x1.5=302
	AVS (036)	Avissawella Dehiowita Labugama	22XXX - 25XXX	4000	2448x1.5=3672

Table 5-3 (A) (3/10) New Numbering Plan Proposed

TSC	SSC	LE	DIRECT NO. (PROPOSED)	CAPACITY in 2000x1.5	DEMAND
CNT	AVS (036)	Kosgama Hanwella Pugoda Waga	55XXX - 57XXX	3000	1636x1.5=2454
		Bulathokupitiya	6XXX	1000	163x1.5=245
		Kithulgala	7XXX	1000	134x1.5=201
		Ehaliyagoda Parakaduwa Yogama	87XXX - 89XXX	3000	1435x1.5=2153
		Deraviyagala	95XXX	1000	316x1.5=474
		Ruwanwella Waharaka Yatiyantota	96XXX - 97XXX	2000	1091x1.5=1637
	KRG (037)	Kurunegala Ibbagamuwa Kohilagedera Maspotha Mawathagama Pothuhera Uhumiya Wellawa	2XXXX - 3XXXX	20000	9935x1.5=14903
		Kuliyapitiya Udabadduwa	41XXX - 43XXX	3000	1711x1.5=2567
		Polgahawela Alawwa	44XXX - 46XXX	3000	1788x1.5=2682
		Wariyapola	47XXX - 48XXX	2000	698x1.5=1047
		Pannala Genawila	49XXX	1000	393x1.5=590
		Maho	50XXX	1000	612x1.5=918
		Giriulla	51XXX	1000	622x1.5=933
		Narammala Katupotha	52XXX - 53XXX	2000	1053x1.5=1580
		Nikaweratiya	54XXX - 55XXX	2000	746x1.5=1119
		Hettipola Kobaigana	56XXX	1000	230x1.5=345
		Ridigama Dodangaslanda Gokarella Rambadagalla	57XXX	1000	537x1.5=806
		Galagmuwa	58XXX	1000	383x1.5=575
		Nikadalupotha	59XXX	1000	134x1.5=201

Table 5-3 (A) (4/10) New Numbering Plan Proposed

TSC	SSC	LE	DIRECT NO. (PROPOSED)	CAPACITY in 2000x1.5	DEMAND
KND	KND (08)	Kandy Gurudeniya Medamaranuwara Talatuoya	22XXXX - 27XXXX	60000	38521x1.5=57782
		Gampola	51XXX - 57XXX	7000	4455x1.5=6683
		Galagedara Hataraliyadda	61XXX - 62XXX	2000	785x1.5=1178
		Madulkele	63XXX	1000	364x1.5=546
		Rikillagaskada Hangwanketla Hewahata	64XXX - 65XXX	2000	957x1.5=1436
		Galaha	66XXX - 67XXX	2000	698x1.5=1047
		Kaduganmawa Menikdiwela	71XXX - 74XXX	4000	2572x1.5=3858
		Digana ElKaduwa Panwila	75XXX - 76XXX	2000	1196x1.5=3858
		Pussellawa	58XXX	1000	603x1.5=905
		Peradeniya Daulgala Gelioya Murutalaiwa	88XXXX - 89XXXX	20000	7505x1.5=11258
		Katugastota Akurana Warallagama	98XXXX - 99XXXX	20000	6988x1.5=10482
	HTN (051)	Hatton Watagoda	21XXXX - 27XXXX	7000	4417x1.5=6626
		Norton Bridge	3XXX	1000	278x1.5=417
		Watawala Ginigathena	7XXX - 8XXX	2000	900x1.5=1350
		Agarapatana	5XXX	1000	517x1.5=776
		Pundaluoya	6XXX	1000	507x1.5=761
		Upcot	4XXX	1000	230x1.5=345
		Tillicountry	9XXX	1000	450x1.5=675

Table 5-3 (A) (5/10) New Numbering Plan Proposed

TSC	SSC	LE	DIRECT NO. (PROPOSED)	CAPACITY in 2000x1.5	DEMAND
KND	NWR (052)	Nuwara Eliya Kandapola Boragas Raddella	22XXXX - 23XXXX	20000	6979x1.5=10469
		Halgranoya	5XXX	1000	526x1.5=789
		Maturata Padiyapelella	6XXX	1000	345x1.5=518
		Ramboda	7XXX	1000	239x1.5=359
		Udapussallawa	8XXX	1000	316x1.5=474
		Watumulla Nildandahinna	9XXX	1000	67x1.5=101
		Talawakele	31XXX - 32XXX	2000	1014x1.5=1521
		Maskeliya	33XXX - 34XXX	2000	775x1.5=1163
		Bagawonytalawa	4XXX	1000	660x1.5=990
	NWL (054)	Nawalapitiya	2XXX - 4XXX 7XXX	4000	2648x1.5=3972
		Kotmale	5XXX	1000	287x1.5=431
		Dolosbage	61XX - 63XX	300	173x1.5=260
		Craig Herd	64XX - 65XX	200	67x1.5=101
	BDL (044)	Badulla Demodara Ettampitiya Glen alpin Haliela	2XXXX	10000	5996x1.5=8994
		Manaragala Buttala	40XXX - 42XXX	3000	1387x1.5;2081
		Mahiyangana	43XXX - 44XXX	2000	813x1.5=1220
		Passara Badalkumbura Lunugala	45XXX - 46XXX	2000	968x1.5=1452
		Padiyatalawa Mehaoya	47XX	1000	135x1.5=203
		Wellawaya	48XX	1000	259x1.5=389
		Namunukula	50XX - 53XX	400	239x1.5=359
		Bibile Medagama	54XX - 59XX	600	403x1.5=605
		Kandaketiya Madulsima	60XX 61XX - 63XX	100 300	29x1.5=44 144x1.5=216

Table 5-3 (A) (6/10) New Numbering Plan Proposed

TSC	SSC	LE	DIRECT NO. (PROPOSED)	CAPACITY in 2000x1.5	DEMAND
KND	BNR (057)	Bandarawela Diyatalawa Ella Malwatta	2XXXX	10000	5088x1.5=7632
		Welimada Gwutalawa	55XXX - 57XXX	3000	1406x1.5=2109
		Ampitikanda	7XXX	1000	211x1.5=317
		Haputale Holdummulla	8XXX	1000	1148x1.5=1722
		Koslanda	9XXX	1000	306x1.5=459
	AMR (063)	Ampara	21XXX - 25XXX	5000	2677x1.5=4016
		Kalmunai	41XXX - 48XXX	8000	5210x1.5=7815
		Akkarapattu	77XXX - 9XXX	3000	1941x1.5=2912
	BTC (065)	Batticaloa	2XXXX - 3XXXX	20000	9224x1.5=13836
		Valachchanai	7XXX - 9XXX	3000	1530x1.5=2295
	MTL	Matale Aukumbura Alawatugoda	2XXXX - 3XXXX	20000	7381x1.5=11087
		Wilgomuwa	5XXX	1000	
		Naula Golewela Kimbissa Nalanda	61XXX - 62XXX	2000	1197x1.5=1796
		Elahara Bakamuna	66XX - 60XX	500	163x1.5=245
		Mahawela Madipola Madawala-ulpoth	71XX - 76XX	600	346x1.5=519
		Dambulla Habarana	88XX - 89XX	2000	909x1.5=1364
		Rottota Gammaduwa Laggala Masua Eliya	4XXX	1000	566x1.5=849

Table 5-3 (A) (7/10) New Numbering Plan Proposed

TSC	SSC	PSC	DIRECT NO. (PROPOSED)	CAPACITY in 2000x1.5	DEMAND
ANR	JFN (021)	Jaffna Atchuvely Chunnakam Kopay Manipay	22XXXX - 27XXXX	60000	37413x1.5=56120
		Karaveddy Point-Pedru Valvetiturai	4XXXX	10000	3854x1.5=5781
		Tellipallai Alaveddi Kankwanturai	5XXXX	10000	1416x1.5=2124
		Sitankerni Panateruppu Vaddukkoddai	6XXXX	10000	1846x1.5=2769
		Kayts Karainagar Velanai	7XXXX	10000	1751x1.5=2627
		Kilinochchi	8XXXX	10000	2285x1.5=3428
		Chavakachcheri	91XXX.96XXX 97XXX	3000	1520x1.5=2280
		Pallai	92XXX	1000	354x1.5=531
		Pooneryn Punakari	93XXX	1000	115x1.5=173
		Punkudutivu Delft Nainativu	94XXX.95XXX	2000	307x1.5=461
		Avarankal			
	MNR (023)	Mannar Errukkalampiddi	22XXX - 25XXX	4000	2046x1.5=3069
		Murunkan Madu Road Madu Church	4XXX	1000	431x1.5=647
		Talaimannar	61XX - 65XX	500	259x1.5=389
		Pesalai	66XX - 69XX	400	144x1.5=216
		Uyilankulam Nantan	71XX - 74XX	400	211x1.5=317
		Adampan	75XX - 77XX	300	134x1.5=201
		Vidalativu	78XX - 79XX	200	58x1.5=87
		Chillavathura	81XX - 82XX	200	96x1.5=144

Table 5-3 (A) (8/10) New Numbering Plan Proposed

TSC	SSC	LE	DIRECT NO. (PROPOSED)	CAPACITY in 2000x1.5	DEMAND
ANR	VNY (024)	Vavuniya Omantai	21XXX - 26XXX	6000	3489x1.5=5234
		Mankulam Tunukai Yogapuram	4XXX	1000	480x1.5=720
		Mulativu	66XXX - 67XXX	2000	717x1.5=1076
		Padaviya	7XXX	1000	106x1.5=159
		Nedunkerni Pathkudiruppu Oddichudan Mulliyawalai	8XXX	1000	471x1.5=707
	ANR (025)	Anuradhapura Mihintale Rambawa Talawa Tiripane	2XXXX - 3XXXX	20000	7410x1.5=1115
		Kekirawa Ipologama Maradankadawela Negampola Vijithapwa	44XXX - 45XXX	2000	1205x1.5=1808
		Medawachchiya Cheddikulam	6XXX	1000	546x1.5=819
		Tambuttegama	70XX - 73XX	400	163x1.5=245
		Kohatagasdigilliya Sippululam Ratmalgahawewa	74XX - 79XX	600	394x1.5=591
		Nochchiyagama	80XX - 83XX	400	220x1.5=330
		Galenbindunuwewa	87XX - 89XX	300	153x1.5=230
		Horowpatana	84XX - 86XX	300	182x1.5=273
		Kebitigollewa	90XX - 93XX	400	220x1.5=330
		Eppawala Galnewa Maha Ibuppallama	4XXX	1000	641x1.5=962
	TRN (026)	Trincomalee	2XXXX	10000	5257x1.5=7886
		China-Bay Kinniya	5XXX	1000	632x1.5=948
		Kantalei	61XX - 67XX	700	431x1.5=647
		Kiliveddi	68XX - 69XX	200	58x1.5=87
		Kuchchaveli	70XX - 74XX	500	77x1.5=116

Table 5-3 (A) (9/10) New Numbering Plan Proposed

TSC	SSC	LE	DIRECT NO. (PROPOSED)	CAPACITY in 2000x1.5	DEMAND
ANR	TRN (026)	Nilaveli	75XX - 79XX	500	268x1.5=402
		Seruwila Toppur	80XX - 81XX	200	68x1.5=102
		Thampalakamam	85XX - 89XX	500	77x1.5=116
		Morawewa Gomarankadawela	90XX - 92XX	300	96x1.5=144
		Pulmudai Padavisipura	93XX - 94XX	200	49x1.5=74
		Mutur	95XX - 99XX	500	278x1.5=417
	PLN (027)	Polonnaruwa	2XXX - 4XXX	3000	1950x1.5=2925
		Hingurakgoda	5XXX - 6XXX	2000	918x1.5=1377
GLE	GLE (09)	Galle Dodanduwa Yakkalamulla	2XXXX - 4XXXX	30000	18305x1.5=27458
		Elpitiya Pitigala	50XXX - 51XXX	2000	852x1.5=1278
		Baddegama	52XXX.58XXX	2000	765x1.5=1148
		Habaraduwa Ahangama	53XXX.59XXX	2000	795x1.5=1193
		Kosgoda Urgasmanhndiya	54XXX	1000	393x1.5=590
		Udagama	55XXX	1000	220x1.5=330
		Imaduwa	56XXX	1000	239x1.5=359
		Talgasewela	57XXX	1000	115x1.5=173
		Ambalangoda	81XXX - 86XXX	6000	3747x1.5=5621
	MTR (041)	Matara	2XXXX - 3XXXX	20000	9731x1.5=14597
		Weligama	51XXX - 53XXX	3000	1625x1.5=2438
		Deniyaya Kotapola	61XXX	1000	718x1.5=1077
		Kanburupitiya Gomila	71XXX	1000	708x1.5=1062
		Dikwella	41XX - 48XX	800	488x1.5=732
		Hakmana Yatiyana Deiyandara	72XXX	1000	441x1.5=662

Table 5-3 (A) (10/10) New Numbering Plan Proposed

TSC	SSC	LE	DIRECT NO. (PROPOSED)	CAPACITY in 2000x1.5	DEMAND
GLE	MTR (041)	Kottegoda	49XX - 40XX	200	125x1.5=188
		Morawaka	52XXX	1000	259x1.5=389
		Telijjawila	54XXX	1000	211x1.5=317
		Urubokka	63XXX	1000	192x1.5=288
		Akuressa	8XXX	1000	631x1.5=947
	RTN (045)	Ratnapura Kuruwita	2XXXX - 3XXXX	20000	7944x1.5=11916
		Pelmadulla Atakalampanna Kahawatta	41XXX - 44XXX	4000	2668x1.5=4002
		Kalawana	50XX - 54XX	500	211x1.5=317
		Kiriella Ayagama	55X.59XX	500	212x1.5=318
		Rakwana Godakawela Kolonne	6XXX	1000	747x1.5=1121
		Balangoda	71XXX - 73XXX	3000	1673x1.5=2510
		Bambarabotuwa	85XX - 89XX	500	134x1.5=201
		Niuitigala	9XXX	1000	708x1.5=1062
	HMB (047)	Hambantota	21XXX - 23XXX	3000	1635x1.5=2453
		Tissamaharama	3XXX	1000	679x1.5=1019
		Kataragama	40XX - 44XX	500	354x1.5=531
		Tanamalwila	45XX - 49XX	500	77x1.5=116
		Ambalantota Hungama	51XXX - 52XXX	2000	804x1.5=1206
		Embilipitiya	53XXX - 544XX	1500	803x1.5=1205
		Thimbolketiya	545XX - 546XX	200	125x1.5=188
		Tongalle	61XXX - 62XXX	2000	1358x1.5=2037
		Beliatta	63XXX	1000	373x1.5=560
		Walasmulla	70XX - 74XX	500	297x1.5=446
		Weeraketiya	75XX - 79XX	500	249x1.5=374
		Middeniya	90XX - 91XX	400	96x1.5=144
		Angunakolapelessa	80XX - 84XX	500	144x1.5=216

Table 5-3 (B) (1/3) New Numbering Plan Proposed (Greater Colombo Area)

SSC		NAME OF EXCHANGE	TYPE OF EQUIPMENT	EXCHANGE CODE (Existing)	DIRECT NO. (PROPOSED)		DEMAND (in 2000x1.5)
CODE	NO.				PHASE 1	PHASE 2	
		COLOMBO SSC					
CNT	1	Angoda	E10-RSU	578	*3 51XXXX-54XXXX	556XXX-559XXX	2396x1.5=3594
	2	Boralesgamuwa	SxS	0794	*5	84XXX-87XXX	2500x1.5=3750
	3	Colombo Central	SxS E10 B	2, 3 540-549	2XXX *1 32XXXX-34XXXX	21XXXXX-23XXXXX	177493x1.5=266240
	4	Co-Havelock Town	SxS E10-RSU	8 580-589 500-503	*4 55XXXX-50XXXX	61XXXXX-62XXXXX	115280x1.5=172920
	5	Co-Maradana	SxS E10-RSU	9 590-599	9XXXX	51XXXXX-52XXXXX	97681x1.5=146522
	6	Hokandara	E10-RSU	5610-5614	*3	566XXX-568XXX	2035x1.5=3053
	7	Homagama	E10-RSU	555	*4	655XXX-658XXX	2688x1.5=4032
	8	Ja-Ela	E10-RSU	536-537	*2 48XXXX-49XXXX	47XXXX	4750x1.5=7125
	9	Kadawata	E10-RSU	525	*2	48XXXX	4445x1.5=8334
	10	Kaduwela	E10-RSU	5710-5714	*3	561XXX-568XXX	3556x1.5=5334

Table 5-3 (B) (2/3) New Numbering Plan Proposed (Greater Colombo Area)

SSC		NAME OF EXCHANGE	TYPE OF EQUIPMENT	EXCHANGE CODE (Existing)	DIRECT NO. (PROPOSED)		DEMAND (in 2000x1.5)
CODE	NO.				PHASE 1	PHASE 2	
CNT	11	Kelaniya	E10-RSU	520-521	*2	41XXXX-43XXXX	16362x1.5=24543
	12	Kotte	E10-RSU	5615-5619 562-569	*3	53XXXXX	45949x1.5=85424
	13	Maharagama	E10-RSU	550-551	*4	64XXXX 651XXX-654XXX	9216x1.5=13824
	14	Malwana (Biyagama)	E10-RSU	5715-5719	*2	466XXX-469XXX	2195x1.5=3293
	15	Moratuwa	SxS	072	*5	81XXXX-82XXXX 831XXX-833XXX	15265x1.5=22898
	16	Mount Lavinia	C400	71	*5 71XXXX-72XXXX	70XXXX-79XXXX	62428x1.5=96372
	17	Nugegoda	E10-RSU	522-524 556-558	*4	631XXXX-636XXXX	41441x1.5=62162
	18	Padukka	E10-RSU	559	*4	66XXX-67XXX	1048x1.5=1574
	19	Piliyandala	SxS	0795	*5	834XXX-838XXX	3417x1.5=5126
	20	Ragama	E10-RSU	538	*2	461XXX-454XXX	3438x1.5=5157
	21	Wattala	E10-RSU	530-531	*2	44XXXX-45XXXX	10772x1.5=16158

Table 5-3 (B) (3/3) New Numbering Plan Proposed (Greater Colombo Area)

SSC		NAME OF EXCHANGE	TYPE OF EQUIPMENT	EXCHANGE CODE (Existing)	DIRECT NO. (PROPOSED)		DEMAND (in 2000x1.5)
CODE	NO.				PHASE 1	PHASE 2	
CNT	22	Wellampitiya	E10-RSU	572	*3	54XXXX 551XXX-555XXX	9813x1.5=14720
	23	Kollupitiya	E10-RSU	573-577	*1	241XXXX-244XXXX	22720x1.5=34080
	24	Mattakkuliya	E10-RSU	523-524	*1	245XXXX-246XXXX	10082x1.5=15123

2. CHARGING PLAN

2.1 Existing Telephone, TELEX, and Telegraph Tariff System

2.1.1 Telephone tariff

Telephone tariff system in Sri Lanka, established on February 1, 1984, appears in Table 5-4. International STD service and operator assisted international call service required deposits of Rs 5,000 and Rs 500, respectively, besides call tariffs.

2.1.2 TELEX tariff

TELEX tariff system established on February 1, 1984, appears in Table 5-5.

2.1.3 Telegraph tariff

Telegraph tariff system appears in Table 5-6.

2.1.4 Other tariffs

(1) Public pay telephone tariff

At present, local calls only are available at public pay telephones. Tariff is Rs 1/call regardless of call duration.

Recommendations for the future are to introduce, for local calls also, tariff by call duration based on 120 seconds as one unit, and to make toll calls also available, adopting multi-metering and charging system based on call duration and call distance.

Coin collecting slot now used at public pay telephones have to be modified should the existing Rs 1 coin be re-shaped or the tariff system be altered, causing another coin to be used. To avoid such trouble and also to prevent the loss of coins by pilferage, it is worth consideration to so arrange that each user should buy token coin at call office counter and pay call tariff with such token coin.

(2) Leased circuit, new service tariffs

For leased circuits and new services, no tariff system exists at present. However, considering that demand is taking shape, tariff system has to be established at any early opportunity.

2.2 Tariff Modification

When service tariffs are modified in the future, matters to be duly considered are as under.

(1) Not to apply pressure on SLTD finance

Modified tariff should be such that it can fully cover necessary expense for handling of each call. Such necessary expense includes initial expense share for equipment used, depreciation expense, annual expense of facilities maintenance, and SLTD manpower expense.

(2) To consider subscribers' purchasability

Telephone diffusion and tariff system are in inverse proportion. Should tariff level exceed

purchasability of subscribers, telephone demand is restrained. As a result, social and economic activities also suffer restraint.

Therefore, tariff modification should preferably be kept within the limits of real currency value fluctuations.

(3) Relationship with new service tariff

Tariff system to be newly established for the expected new services must be balanced with tariff system for the existing telephone and TELEX services.

2.3 Charging Equipment

CAMA (Centralized Automatic Message Accounting) equipment is to be installed at four TSCs by IDA Project. With CAMA, charging data for each toll call are recorded on magnetic tape by detailed billing system. Such magnetic tapes are transferred to Colombo Charging Center where they are processed en masse by computer system. However, in Colombo area, the number of subscribers will increase conspicuously in the future so that CAMA system with charging equipment installed at each local exchange will be adopted.

At present, data transmission from each TSC to Colombo Charging Center is by magnetic tape transportation. In the future, high speed data transmission by digital data circuits is to be realized.

Table 5-4 (1/2) Telecommunication Tariffs
(As of December, 1984)

TELEPHONE

(1) Connection Fees

Central Colombo STD exchanges:	Minimum - Rs. 10,000
Other STD exchanges:	Minimum - Rs. 7,000
Exchanges other than STD:	Minimum - Rs. 2,500

(2) Annual Rentals

Business:	Rs. 900
Residence:	Rs. 360
Religious institutions:	Rs. 200

(3) Local Call Charges

For every 120 seconds:	Rs. 0.90

In the Greater Colombo Area, there are several stations within which local calls are charged on an untimed basis; however they are expected to be converted to a times basis by 1987.

LONG DISTANCE CALLS

(1) Manual Exchanges

	Every 3 minutes	
	6 am - 9 pm	9 pm - 6 am
Within the same Group Switching Center	Rs. 1.00	Rs. 1.00
Less than 64 km	Rs. 3.00	Rs. 1.50
Between 64 km - 177 km	Rs. 4.00	Rs. 2.00
Over 177 km	Rs. 6.00	Rs. 3.00

(2) Operator Connected STD

	Every 3 minutes		Every additional 3 minutes	
	6 am-9 pm	9 pm-6 am	6 am-9 pm	9 pm-6 am
With the same Group Switching Center	Rs. 2.65	2.65	1.65	1.65
Less than 32 km	4.30	2.65	3.30	1.65
Between 32 km - 80 km	6.40	3.70	5.40	2.70
Between 80 km - 122 km	10.00	5.50	9.00	4.50
Between 112 km - 193 km	11.80	6.40	10.80	5.40
Over 193 km	17.20	9.10	16.20	8.10

Table 5-4 (2/2) Telecommunication Tariffs
(As of December, 1984)

(3) Directly Dialled STD

	Per Rs. 0.90	
	6 am - 9 pm	9 pm - 6 am
Within the same Group Switching Center	100 seconds	100 seconds
Less than 32 km	50	100
Between 32 km - 80 km	30	60
Between 80 km - 112 km	18	36
Between 112 km - 193 km	15	30
Over 193 km	10	20

(4) International Calls

	Directly dialled		Operator connected
Station to Station Calls to:	Per minute	First 3 minutes	Every additional minutes
India	Rs. 40	Rs. 120	Rs. 40
Japan	54	162	54
Saudi Arabia	62	186	62
Singapore	54	162	54
U.K.	54	162	54
U.S.A.	62	186	62

Table 5-5 TELEX Tariff

(1) Connection Fees:	Rs. 200		
(2) Annual Rentals			
Telex Machines:	Rs. 36,000		
Circuits (per mile):	Rs. 15,000		
(3) Call Charges			
	Automatic	Operator connected	
Station to Station Calls to:	Per minute	First 3 minutes	Every additional minutes
India	Rs. 41	Rs. 123	Rs. 41
Japan	48	144	48
Saudi Arabia	54	162	54
Singapore	48	144	48
U.K.	48	144	48
U.S.A.	54	162	54

Table 5-6 Telegraph Tariff

Telegram		
Ordinary	10 words or less	Rs. 1.00
	Each additional word	Rs. 0.15
Express	10 words or less	Rs. 2.00
	Each additional word	Rs. 0.30
Press	100 words or less	Rs. 5.00
	Each block of additional 50 words or less	Rs. 2.50
Deposits for Telegram For 25 Telegrams or less within one quarter of a year		Rs.20.00

3. ROUTING PLAN

3.1 Exchange Hierarchy

Toll network zones are classified by the following three exchange hierarchies:

A. Tertiary Switching Center (TSC)

B. Secondary Switching Center (SSC)

C. Local Exchange (LE)

In case where exchange establishment plan is specified, Satellite Office (SO) is considered besides the above three. For international network, International Switching Center (ISC) is established. For gate office between ISC and national network, National Switching Center (NSC) is established.

TSC is established at four cities, i.e., Colombo, Kandy, Galle and Anuradapura.

SSC is established at 29 cities as listed in Table 5-7.

At SSC, manual switch-board is established, in principle, to provide such special services as directory service and operator toll connection.

Table 5-7 Secondary Switching Center (SSC) Allocations

TSC	SSC
Colombo	Total: 9 Colombo, Chillaw, Kurunegala, Negombo, Kegalle, Gampaha, Avissawella, Panadura, Kalutara
Kandy	Total: 10 Kandy, Batticaloa, Matale, Nawalapitiya, Nuwara Eliya, Badulla, Hatton, Bandarawela, Ampara, Kalmunai
Galle	Total: 4 Galle, Ratnapura, Matara, Hambantota
Anuradapura	Total: 6 Anuradapura, Jaffna, Mannar, Vavuniya, Trincomallee, Polonnaruwa

3.2 Network Configuration

3.2.1 Toll circuit

Toll circuits are classified into three types. They are:

A. Backbone circuit

Backbone circuit connects an exchange to a higher ranking exchange to which the former belongs in accordance with exchange hierarchy. Backbone circuit is established between TSCs also.

B. High usage circuit

High usage circuit is other circuit than backbone circuit. High usage circuit is established in case where considerable call volume exists between any two exchanges and where network configuration economy can be realized.

C. Exclusive international circuit

Called FP (Fully Provided Route) circuit is established directly from SSC to NSC-ISC, to be exclusively used for international calls.

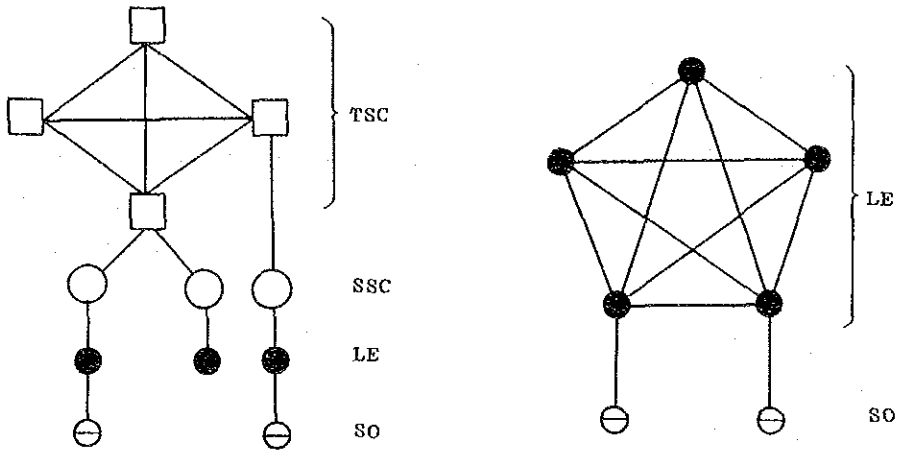
Purposes of establishing FP are twofold. One is to secure international circuit independent of national toll circuit which is relatively small in capacity and becomes wholly occupied when traffic increases unexpectedly. The other is to avoid difficulty of offering signals and calling subscriber number verification signal transmission from ISC by way of general backbone circuit. (In this case, FP is established from ISC-NSC directly to SSC.)

However, as toll network becomes fully equipped from now forward and, at the same time, as R2 signal and digital switching equipment are introduced, making signal transmission easy, FP becomes less and less necessary. Therefore, after 1990, FP is to be incorporated into general toll circuit.

3.2.2 Network configuration

Standard network configuration appears in Figure 5-1.

A. TSC - TSC: Mesh type
B. TSC - SSC: Star type
C. SSC - LE: Star type
D. Multi-exchange area: Mesh type



1) Toll Network

2) Local Network in Multi-Exchange Area

Figure 5-1 Network Configuration

3.3 Grade of Service

3.3.1 Overall grade of service

Grade of services between arbitrarily chosen two LEs are as under.

A. Toll connection: Less than 7%
B. Local connection: Less than 4%

3.3.2 Loss probability distribution

Loss probability distribution to each circuit section is as under.

A. 1 stage of backbone circuit: 1%
B. Manual SSC - LE: 3%
C. Multi-exchange area
   LE - LE: 2%
   LE - SE: 1%

3.4 International Network

All international calls are concentrated at National Switching Center (NSC), Colombo, via FP at present and via general toll circuit in the future, and are switched at International Switching Center (ISC).

4. TRANSMISSION PLAN

4.1 Introduction

Main objective of transmission plan is to determine correctly transmission quality distribution in digitalized national telephone network and make sure of required speech quality of national and international calls at reasonable cost.

Transmission plan contains "Error Performance Objectives for Digital Connection". This is in consideration of possibilities that telecommunication services may be provided by integrated service digital network (ISDN) in the future.

4.2 Standard for Transmission Quality Distribution

4.2.1 Transmission quality measurement

Generally, transmission quality of telephone circuit is expressed by reference equivalent (RE). Now, by International Telegraph and Telephone Consultative Committee (CCITT), speech quality measuring unit is being changed from RE to LR (loudness rating) though the use of RE is still admitted. At the present stage, RE is more commonly used than LR. Therefore, in this transmission plan also, RE is adopted as transmission quality measuring unit.

4.2.2 Transmission quality requirement

Transmission quality must be such that the most part of subscribers can be satisfied in telephone conversations. To reduce transmission loss of subscriber's line,

conductor diameter must be increased. This requires a large amount of investment.

On the other hand, reducing transmission loss of carrier circuit requires no extra investment.

Thus, on backbone route between two local exchanges, technically possible minimum transmission loss is distributed. Concretely speaking, minimum transmission loss is determined by the degree of stability and echo of 4-wire circuit.

Telephone circuit RE is equal to transmission loss measured by the undermentioned reference frequencies.

(a) In case of carrier circuit or loaded circuit: 800 Hz

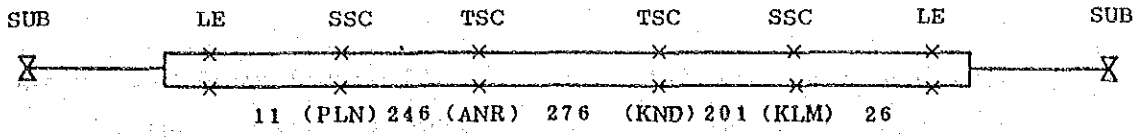
(b) In case of non-loaded circuit (including subscriber's line): 1,600 Hz

4.3 RE Distribution Standard

4.3.1 Circuit configuration for national connection

As stated in paragraph 3, ROUTING PLAN, almost all parts of telecommunication networks will be digitalized in the year 2000. On this assumption, circuit configuration considered to be the longest is taken up for study.

Circuit configuration considered to be the longest in Sri Lanka is illustrated below.



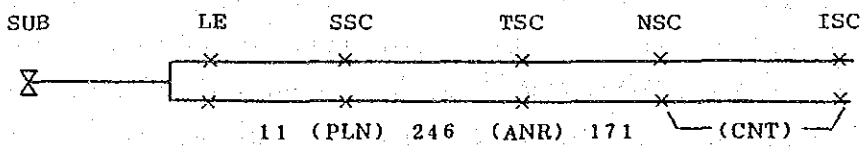
Note: Numeral denotes transmission route distance in km.

PLN: Polonnaruwa
ANR: Anuradapura
KND: Kandy
KLM: Kalmunai

Longest Transmission Route in Sri Lanka

4.3.2 National circuit configuration for international connection

National circuit configuration for international connection is illustrated below.



Note: Numeral denotes transmission route distance in km.

PLN: Polonnaruwa
ANR: Anuradapura
CNT: Colombo

National Circuit Configuration
for International Connection

4.3.3 Stability and echo

Minimum transmission loss is influenced by 4-wire loop singing and echo. In digitalized circuit, digital switch interfaces with subscriber circuit which is analog 2-wire circuit so that loop loss of 4-wire loop of the switch and propagation delay exert influence on transmission loss. Hence the need to determine transmission loss from the viewpoint of circuit stability and echo.

Digital subscriber switch holds 2-wire/4-wire hybrid terminating set to connect 2-wire subscriber line and 4-wire switching circuit. Therefore, balance return loss at terminating set influences loop loss of 4-wire loop.

Balance return loss is determined by subscriber line impedance characteristic and balancing network of hybrid terminating set. Subscriber line impedance characteristic varies broadly from one case to another so that it is important to identify this characteristic correctly.

Data concerning subscriber line impedance in Sri Lanka is not available. This time, the objective value of balance return loss described in CCITT Rec. G.121 is adopted. According to CCITT Rec. 121, stability balance return loss and echo balance return loss mean value objectives are as under.

Stability balance return loss: 6 dB, minimum

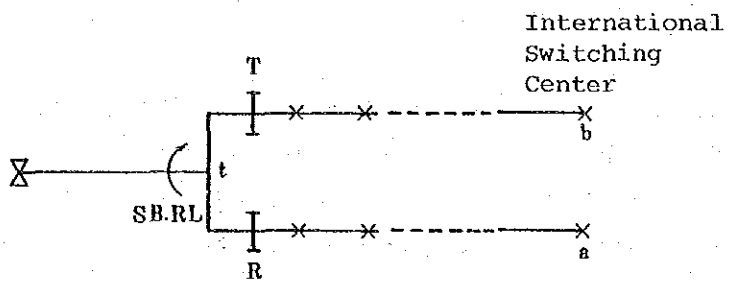
Echo balance return loss: 11 dB, minimum

4.4 Transmission Loss Distribution Plan

4.4.1 Stability

(1) National circuit for international connection

Circuit configuration is as under.



where
a, b: Virtual analog switching point
t: 2-wire/4-wire hybrid conversion point
SBRL: Stability balance return loss

National Circuit for International Connection

According to CCITT Rec. G.122, mean value of transmission loss of the path a-t-b in the circuit configuration shown above must satisfy

$$L_{a\text{-}t\text{-}b} \geq 10 + n \ (dB)$$

where n denotes the number of links in analog 4-wire circuit.

In digital circuit, it is possible to eliminate transmission line loss, making it 0 dB, and loss fluctuation is negligibly small. Therefore, circuit loss is determined by the value of pads to

be inserted in 4-wire section of subscriber switch. (In the illustration above, pads are shown by T and R.) Accordingly, transmission loss of the path a-t-b, i.e., L a-t-b, can be expressed as

$$\begin{aligned} L\ a\text{-}t\text{-}b &= L\ a\text{-}t + SBRL + L\ t\text{-}b \\ &= T + R + SBRL \end{aligned}$$

where, SBRL denotes the stability balance return loss.

CCITT Rec. G.121 states that considering SBRL of 0 dB in the worst case, the sum of pad T and pad R must be 6 dB at a minimum. Table 5-8 presents the value of pads adopted in various countries of the world.

Here, study is made on the assumption of T + R = 7 dB (T = 0 dB; R = 7 dB).

Circuit configuration shown in paragraph 4.3.2 is taken up for study. Although all switches and transmission lines will be digitalized ultimately, International Switching Center will continue to be operated by analog switching system for a considerably long time to come so that study is made on condition that the link between National Switching Center (NSC) and International Switching Center (ISC) be the analog link. Therefore, the foregoing formula can be replaced by

$$\begin{aligned} T + R + SBRL &\geqq 10 + 2 \quad (dB) \\ 7 + SBRL &\geqq 12 \quad (dB) \end{aligned}$$

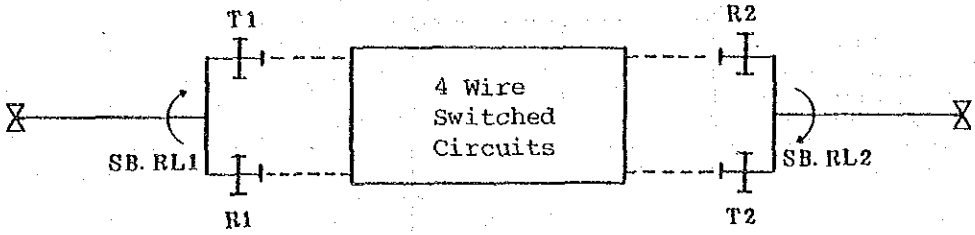
Assuming that mean value of SBRL can be obtained at 6 dB at a minimum as stated in paragraph 4.3.3, the above formulas can be satisfied.

Table 5-8 Values of R and T for Various Countries (G.121)

	Connection Type					
	Own Exchange		Local via a Digital Local Tandem		Trunk via Digital Trunk Exchanges	
	RdB	TdB	RdB	TdB	RdB	TdB
Germany (F.R.) (For subscribers on short lines: R-10 dB, T-3 dB)	7.0	0	7.0	0	7.0	0
Australia	6	0	6	0	6	0
Austria	7	0	7	0	7	0
Belgium	7	0	7	0	7	0
Canada	0	0	3	0	6	0
Denmark	6	0	6	0	6	0
Spain	7	0	7	0	7	0
United States	3	0	6	0	7	0
Finland	7	0	7	0	7	0
France	7	0	- (Not used)	- (Not used)	7	0
India	6	0	6	0	6	0
Italy	7	0	7	0	7	0
Japan	4	0	8	0	8	0
Norway	5	2	5	2	5	2
United Kingdom (Values shown are for median lines: additional loss is introduced on short local lines in both directions of transmission)	6	1	6	1	6	1
Sweden	5	0	5	0	5 (Nat.) 7 (Int.)	0 (Nat.) 0 (Int.)
USSR	7	0	7	0	7	0
Yugoslavia	7	0	7	0	7	0
New Zealand	7	0.5	7.0	0.5	7	0.5

(2) Circuit for national connection

Circuit configuration in the form of equivalent circuit is as under.



For national circuit, mean value of 4-wire loop loss to obtain required stability must be 2 (10 + n) or more. That is to say,

$$(R1 + SBRL\ 1 + T1) + (R2 + SBRL\ 2 + T2) \geqq 2\ (10 + n)\ (dB)$$

In this transmission plan, digitalization of all national circuits is the objective. Therefore, n = 0 is a safe assumption.

When the foregoing formula is applied to circuit configuration shown in Section 4.3.1, the result is

$$7 + SBRL\ 1 + 7 + SBRL\ 2 =$$
$$14 + (SBRL\ 1 + SBRL\ 2) \geqq 20\ (dB)$$

Assuming that mean values of SBRL 1 and SBRL 2 be 6 dB or more, respectively, the above requirement can be satisfied.

4.4.2 Echo study

(1) National circuit for international connection

In order to minimize the influence of echo of international connection calls as per CCITT Rec. G.122, mean value of transmission loss of the path a-t-b must be (15 + n) dB or more. That is to say,

$$Le\ a\text{-}t\text{-}b \geq 15 + n\ (dB)$$

Echo loss of the path a-t-b, i.e., Le a-t-b, can be expressed as

$$Le\ a\text{-}t\text{-}b = R + T + EBRL$$

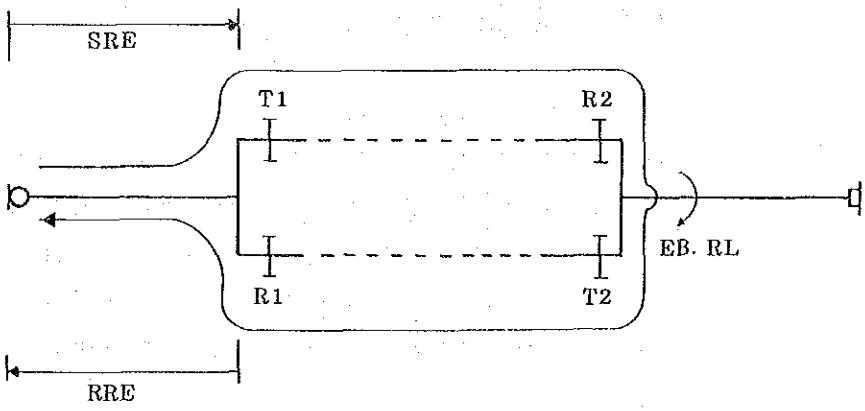
where EBRL is echo balance return loss. Therefore, the formula that applies is

$$7 + EBRL \geq 15 + 1\ (dB)$$

Thus, as stated in Section 4.3.3, when the objective value of EBRL is 11 dB at a minimum, the above requirement can be satisfied.

(2) Circuit for national connection

In the case of national connection, echo route of talker's echo and RE in echo path are as under.



Relationship between RE of echo path and transmission delay time is regulated in CCITT Rec. G.131. It is graphically presented in Figure 5-2. Propagation time by transmission systems are presented in CCITT Rec. G.114. They are listed in Table 5-9.

In the case of circuit configuration shown in paragraph 4.3.1, one-way propagation time is as under.

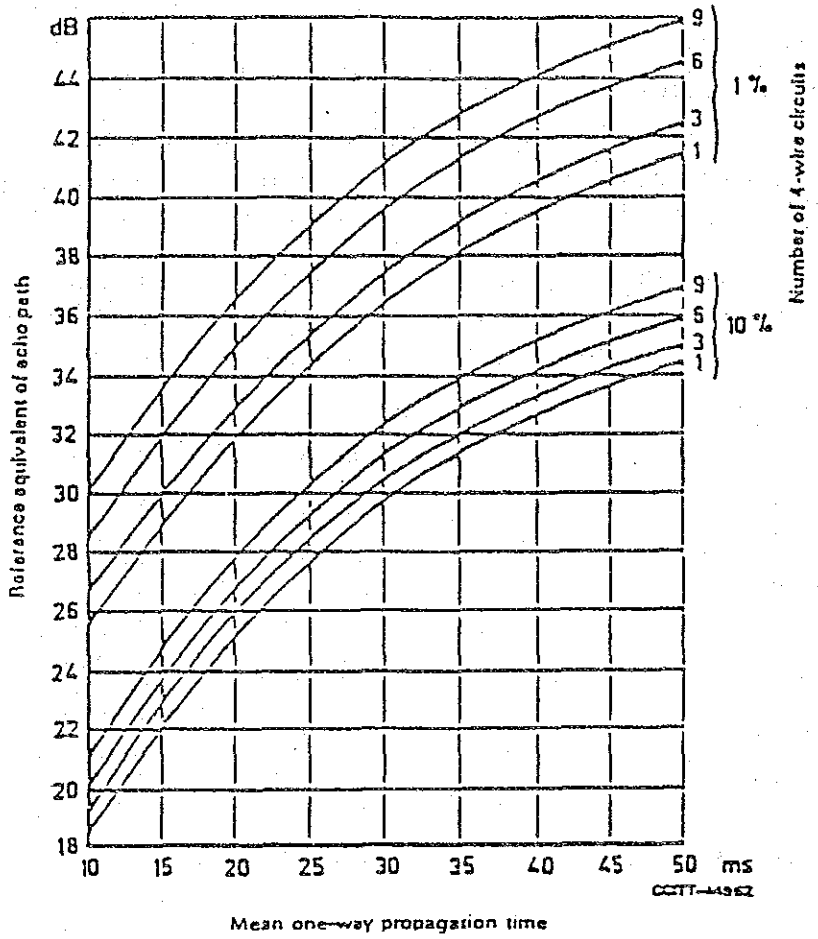
Digital transmission route	760 km	3.0 ms
Digital switch (LS)	2 exchanges	3.0 ms
Digital switch (TS)	4 exchanges	1.8 ms
Total		7.8 ms

Thus, from Figure 5-2, allowable RE of echo path is set at 24 dB or more at risk rate of 1%.

Sending RE (SRE) of subscriber system depends upon the way of telephone set and subscriber's cable combination. This time, based on specifications adopted in Sri Lanka, RE at the time of connection to subscriber's line wherein conductor diameter is 0.5 mm and cable loss is 8 dB is determined as under.

Sending RE (SRE): 10 dB
Receiving RE (RRE): -1 dB

As for national circuit for international connection, CCITT Rec. G.121 recommends that SRE in the section from subscriber to international switching point should be 6 dB or more at a minimum. To satisfy this requirement, near subscribers usually have a pad inserted in their telephone sets.



Notes: 1. The percentages refer to the probability of encountering objectionable echo.

2. The reference equivalent of the echo path is here defined as the sum of:

   - the values of the transmission loss in the two directios of transmission between the 2-wire end of the talking subscriber's line in the terminal local exchange and the 2-wire terminals of the 4W/2W terminating set at the listener's end;
   - the mean value of the echo balance return loss at the listener's end; and
   - the simultaneous-minimum sending and receiving reference equivalents of subscribers' telephone sets and lines at the talker's local exchange.

Figure 5-2 Echo Tolerance Curve (G.131)

Table 5-9 Propagation Time by Transmission Systems (G.114)

Transmission medium	Contribution to one-way propagation time	Remarks
Terrestrial coaxial cable or radio relay system; FDM and digital transmission	4 μs/km	Allows for delay in repeaters and regenerators
Optical fibre cable system; digital transmission	5 μs/km	Allows for delay in repeaters and regenerators
Submarine coaxial cable system	6 μs/km	
Satellite system - 14,000 km altitude - 36,000 km altitude	 110 ms 260 ms	 Between earth stations only
FDM channel modulator or demodulator	0.75 ms[a)]	Half the sum of propagation times in both directions of transmission
FDM compandored channel modulator or demodulator	0.5 ms[b)]	
PCM coder or decoder	0.3 ms[a)]	
PCM-to-ADPCM-to-PCM transcoding	0.5 ms	
Transmultiplexer	1.5 ms[c)]	
Digital transit exchange, digital-digital	0.45 ms[d)]	
Digital local exchange, analogue-analogue	1.5 ms[d)]	
Echo cancellers	1 ms[e)]	

a) These values allow for group-delay distortion around frequencies of peak speech energy and for delay of intermediate higher order multiplex and through-connecting equipment.

b) This value refers to FDM equipments designed to be used with a compandor and special filters.

c) For satellite digital communications where the transmultiplexer is located at the each station, this value may be increased to 3.3 ms.

d) These are mean values: depending on traffic loading, higher values can be encountered, e.g. 0.75 ms (1.925 ms) with 0.95 probability of not exceeding. (For details see Recommendations Q.507 and Q.517.)

e) Echo cancellers, when placed in service, will add a one-way propagation time of up to 1 ms in the send path of each echo canceller. This delay excludes the delay through any coded in the echo canceller. No significant delay should be incurred in the receive path of the echo canceller.

Here, the assumption is to use a pad of 3 dB. Under this condition,

SRE = 5 dB
RRE = -6 dB
T1 = T2 = 0 dB
R1 = R2 = 7 dB

When these values are substituted in the formula to obtain RE of echo path, the result is

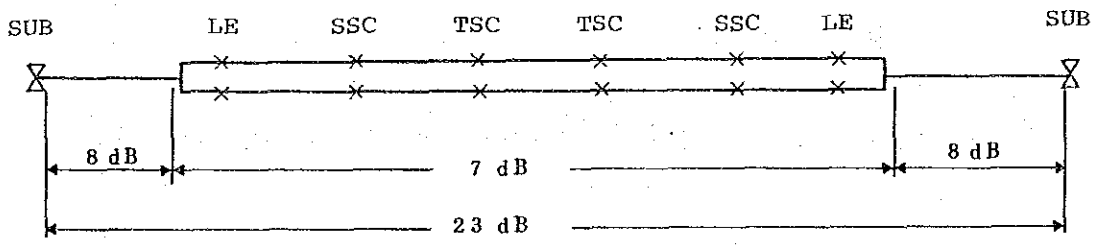
RE echo = 13 + EBRL

As the objective value of EBRL is 11 dB, the risk rate of 1% is satisfied.

4.4.3 Transmission loss distribution plan

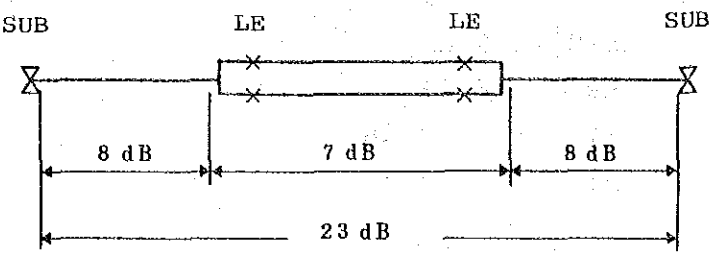
Based on stability and echo conditions examined in paragraphs 4.4.1 and 4.4.2, transmission loss is distributed as illustrated below.

(1) Toll connection



Transmission Loss Distribution (Toll Connection)

(2) Local connection

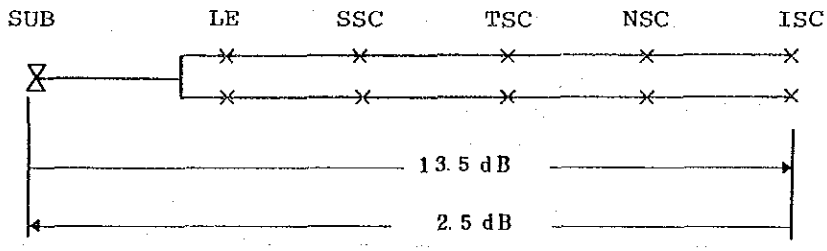


Transmission Loss Distribution (Local Connection)

4.5 Reference Equivalent (RE)

RE of each connection based on loss distribution plan made in paragraph 4.4 is described below.

(1) International connection



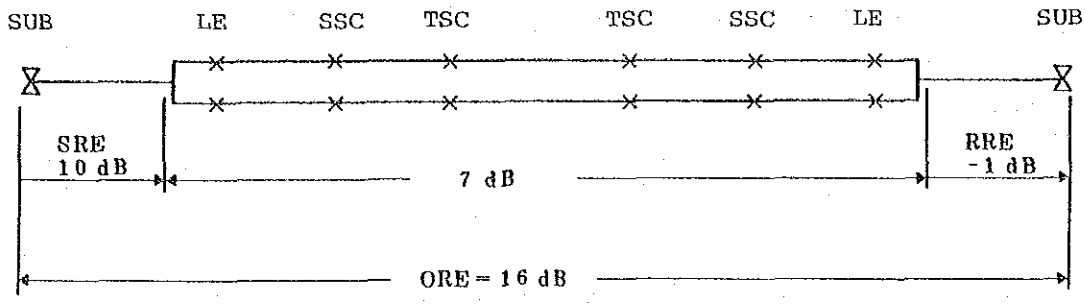
Reference Equivalent (International Connection)

For RE of national circuit for international connection, CCITT Rec. G.121 recommends as under.

SRE: 21 dB
RRE: 12 dB

RE distribution in the above illustration complies with CCITT recommendation.

(2) National connection



Reference Equivalent (National Connection)

CCITT Rec. G.111 states that the desirable range of overall RE by subjective evaluation is from 6 to 18 dB. CCITT further recommends that the long term objective for overall RE in transmission plan should be 13 to 18 dB.

RE distribution in the above illustration complies with those CCITT recommendations.

4.6 Error Performance Objective for Digital Connection

The error performance objectives established in this transmission plan are in accordance with CCITT Rec. G.821.

Purposes of establishing objectives are twofold. They are:

(a) To facilitate service planning and terminal equipment designing by showing the expected bit error characteristics of future digital network.

(b) To obtain precedent whereby to establish standards of ISDN transmission equipment and system characteristics.

4.6.1 Basic considerations

(1) Scope of application

The performance objectives are stated for both direction of 64 kbit/s circuit-switched connection used for telephony and for a "bearer channel" for data-type services.

(2) Error performance parameter

The performance objective is stated in terms of error performance parameters each of which is defined as follows:

"The percentage of averaging periods each of time interval To (To = one minute or one second) during which the bit error ratio (BER) exceeds the threshold value. The percentage is assessed over a period of the order of any month."

(3) Error contribution from network component

No account is taken for error contribution from either digital switching elements or digital multiplex equipments on the basis that it is negligible in comparison with the contribution from transmission systems.

4.6.2 Error performance objectives for international ISDN connections

International ISDN connections should meet all of the requirements fo the following table concurrently. (Refer to CCITT Rec. G.821.)

Error Performance Objectives for International ISDN Connections

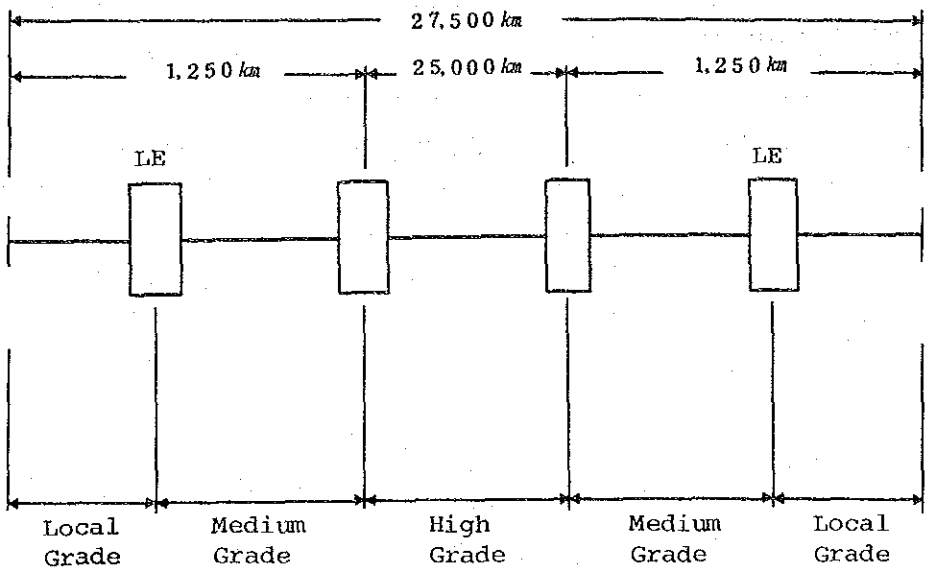
Performance Classification	Objective
(a) Degraded Minutes	Fewer than 10% of one minute intervals to have a bit error ratio worse than 1×10^{-6}
(b) Severely Errored Seconds	Fewer than 0.2% of one second intervals to have a bit error ratio worse than 1×10^{-3}
(c) Errored Seconds	Fewer than 8% of one second intervals to have any errors (equivalent to 92% error free seconds)

4.6.3 Allocation of the error performance objectives

(1) Circuit quality demarcation of the international ISDN connection

Objective values given in Table 4-6 are for overall connections so that these values must be subdivided constituent parts.

Three distinct quality classifications have been indentified representative of practical digital transmission circuit and are independent of the transmission systems used. These classifications are termed local grade, medium grade and high grade and their usage generally tends to be dependent on their location within a network. (Refer to Figure below.)



Circuit Quality Demarcation of International ISDN Connection

(2) Allocation method of the objectives

(a) Degraded minutes and errored seconds

The permitted degradations, i.e., 10% degraded minutes and 8% errored seconds, are allocated for the three circuit classifications as shown in Table below.

Allocation of Degraded Minutes and Errored Seconds Objectives

Circuit Classification	Distribution
Local grade (2 ends)	15% block allowance to each end
Medium grade (2 ends)	15% block allowance to each end
High grade	40%

(b) Severely errored seconds

The total allocation of 0.2% severely errored seconds is subdivided into each circuit classification in the following manner:

(i) 0.1% is divided between the three circuit classifications in the same proportions as adopted for the other two objectives (see Table 3-2).

(ii) The remaining 0.1% is a block allowance to medium and high grade classifications to accommodate the occurrence of adverse network conditions occasionally experienced (intended to mean the worst month of the year) on transmission systems.

(3) Distribution of objectives by grades

The application of the preceding item (2) to the paragraph 4.6.2 results in the allocation of the objectives for the circuit classifications. (Refer to Table below.)

Allocation of the Objectives for the Circuit Classification

	Bit Error Characteristics Objectives at 64 Kbit/s		
	(a) Degraded Minutes	(b) Severely Errored Seconds	(c) Errored Seconds
Local grade	1.5%	0.015%	1.2%
Medium grade	1.5%	0.015%	1.2%
High grade	4.0% (0.00016%/km)	0.04% (0.004%/12,500 km)	3.2% (0.000128%/km)

Note: The block allowances for the local and medium grade portions of the connection may be allocated as necessary within the total allowance of 3%, 0.03% or 2.4% for any one end of the connection.

5. SIGNALLING SYSTEM

5.1 Existing Signalling system

At present, for signalling between step-by-step switching systems and between step-by-step and other switching systems, DP signal is used. For signalling between electronic switching systems, between crossbar switching systems and between electronic and crossbar switching systems, R2 (MFC) signal of CCITT standard is used.

R2 signalling system is divided into two sub-systems, one for analog switching and the other for digital switching. For signalling between digital switching systems, digital R2 system is used. For signalling between analog switching systems and between digital and analog switching systems, analog R2 system is used.

On toll circuit, connections are by analog circuit in almost all cases at present. Therefore, even for signalling between digital switching system, analog R2 system is used. When CADS IV Project is completed, step-by-step exchanges will no longer exist in Greater Colombo Area so that signalling in that area will be solely by R2 system.

5.2 Signalling System Details

5.2.1 Line supervisory signal

(1) E&M signal

E&M signal is for carrier circuit. Out-of-band 3,825 Hz signal is used.

(2) DC loop signal

DC loop signal is for metallic circuit. This signal is for make and break of loop and for polarity reversal.

5.2.2 Register signal

(1) DP signal

8 PPS - 12 PPS

(2) R2 signal

A. Analog R2 signal

Analog R2 signal is used for signalling between analog (crossbar) switching systems and between digital and analog switching systems.

Signal frequency to be used is to comply with relevant CCITT recommendation.

Table 5-10 presents R2 signal implications currently used by SLTD.

B. Digital R2 signal

Digital R2 signal is used for signalling between digital switching systems. Signal specifications are in accordance with CCITT Rec. Q.421, Q.422 and Q.424.

Table 5-11 presents digital R2 signal code classification for PCM circuit in normal state.

5.3 Signal Tones

Singal tones applied in Sri Lanka at present differ from one switching system to another. Currently used signal tones are in Table 5-12.

Difference of signal tones according to switching systems is confusing to subscribers, causing incomplete, unsuccessful calls which can otherwise be avoided. Therefore, for switching systems to be newly introduced from now forward, signal tones should be standardized and recommended to two categories: to E 10 B exchange tone specifications in Colombo with adequate NUT (Number Unobtainable Tone) and to NEAX 61 exchange tone specifications in other cities than Colombo.

Table 5-10 (1/2) R2 Forward Signal Implications

Signal No.	Group I	Group II
1	Digit 1	Subscriber initiated call
2	Digit 2	--
3	Digit 3	--
4	Digit 4	CCB. Sub. initiated call
5	Digit 5	Operator initiated call
6	Digit 6	--
7	Digit 7	--
8	Digit 8	--
9	Digit 9	--
10	Digit 0	--
11	Access to interception	Spare
12	Spare	Spare
13	Access to maintenance equipment	Spare
14	Spare	Spare
15	End of A-number	No information about the A-party's category

Table 5-10 (2/2) R2 Backward Signal Implications

Signal No.	Group I	Group II
1	Send next digit (N+1)	--
2	Send last but one digit (N-1)	--
3	Change to reception of B. sig.	Subscriber engaged
4	Congestion	Congestion
5	Send category of A-party Send number of A-party	NU Tone (Not used at present)
6	Set up speech conditions	Subscriber line free with metering
7	Send last digit but two (n-2)	Subscriber line free without metering
8	Send last digit but three (n-3) (Not used at present)	--
9	--	--
10	--	--
11	--	--
12	--	--
13	--	--
14	--	--
15	--	--

Table 5-11 Digital R2 Signal Code Classification

STATE OF CIRCUIT	SIGNALLING			
	FORWARD		BACKWARD	
	a_f	b_f	a_b	b_b
Idle/Released	1	0	1	0
Seized	0	0	1	0
Seized acknowledged	0	0	1	1
Answered	0	0	0	1
Clear-back	0	0	1	1
Clear-forward	1	0	0 or 1	1 or 1
Blocked	1	0	1	1

Table 5-12 List of Signalling Tones

	Frequency (Hz)	Periodicity (sec)
STROWGER exchanges		
Dial tone	50	Continuous
Ringing tone	400 + 50 Hz	0.4 ON/0.2 OFF/0.4 ON/2.0 OFF
Busy tone	400	0.75 ON/0.75 OFF
NUT	400	Continuous
Crossbar exchanges		
Dial tone	400	Continuous
Ringing tone	400	0.4 ON/0.2 OFF/0.4 ON/2.0 OFF
Busy tone	400	0.5 ON/0.5 OFF
NUT	400	Continuous
NEAX 61 exchanges		
Dial tone	400	Continuous
Ringing tone	400	0.4 ON/0.2 OFF/0.4 ON/2.0 OFF
Busy tone	400	0.75 ON/0.75 OFF
NUT	400	Continuous
E10 B exchanges		
Dial tone	425 ±5	Continuous
Ringing tone	425 ±5	0.4 ON/0.2 OFF/0.4 ON/2.0 OFF
Busy tone	425 ±5	0.75 ON/0.75 OFF
Process tone	425 ±5	0.05 ON/0.05 OFF

6. NETWORK SYNCHRONIZATION PLAN

6.1 Network Synchronization Method

Principle of digital network operation is to transmit a plural number of information by one highway on time division basis. Thus, for divided time measurement, accurate clock frequency synchronization is necessary for all digital exchanges and digital transmission routes in the network.

If synchronization goes wrong, omission or duplication of information takes place periodically. This causes click-like noise to occur on voice circuit and causes data circuit to transmit erroneous data.

Methods to synchronize clock frequency are threefold. They are:

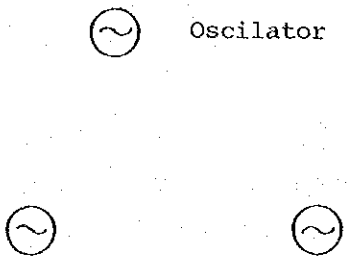
A. Independent Synchronization to make each clock source in the network fully independent.

B. Mutual Synchronization, i.e., multiple loop control system controls the exchange frequency by means of phase difference between own exchange clock source and other exchange clock source in the network.

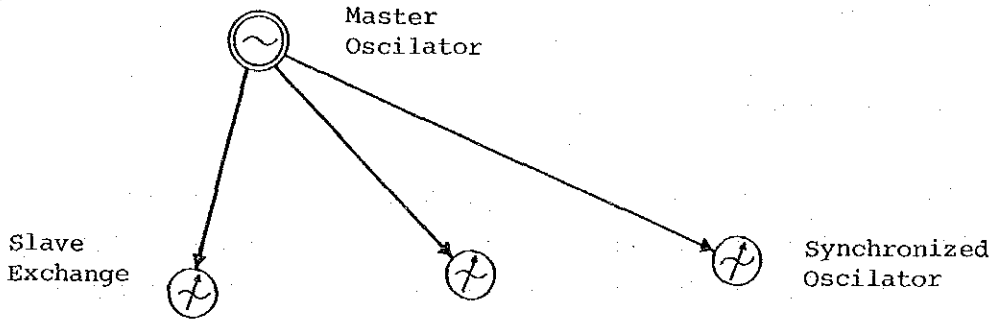
C. Master-slave Synchronization to use specific exchange in the network as master exchange and other exchanges as slave exchanges, causing the latter to depend upon the former in clock operation.

Conceptual diagrams of three frequency synchronization methods follow:

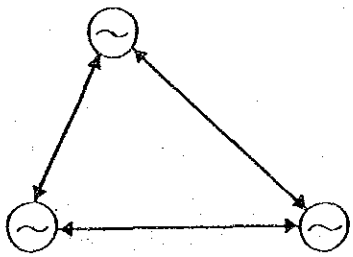
Independent Synchronization



Master-slave Synchronization



Mutual Synchronization



Methods of Frequency Synchronization

These three frequency synchronizations are respectively featured as under.

6.1.1 Independent synchronization

Fixed oscillator is installed at each exchange. This fact facilitates network expansion when necessary. Even if fixed oscillator at one exchange fails, fixed oscillators at other exchanges remain unaffected. However, this synchronization method requires high precision technology to the extent of 10^{-10} - 10^{-11} to keep oscillators at work, and such high precision can be attained by caesium element oscillator or the like only. Hence high cost.

6.1.2 Mutual synchronization

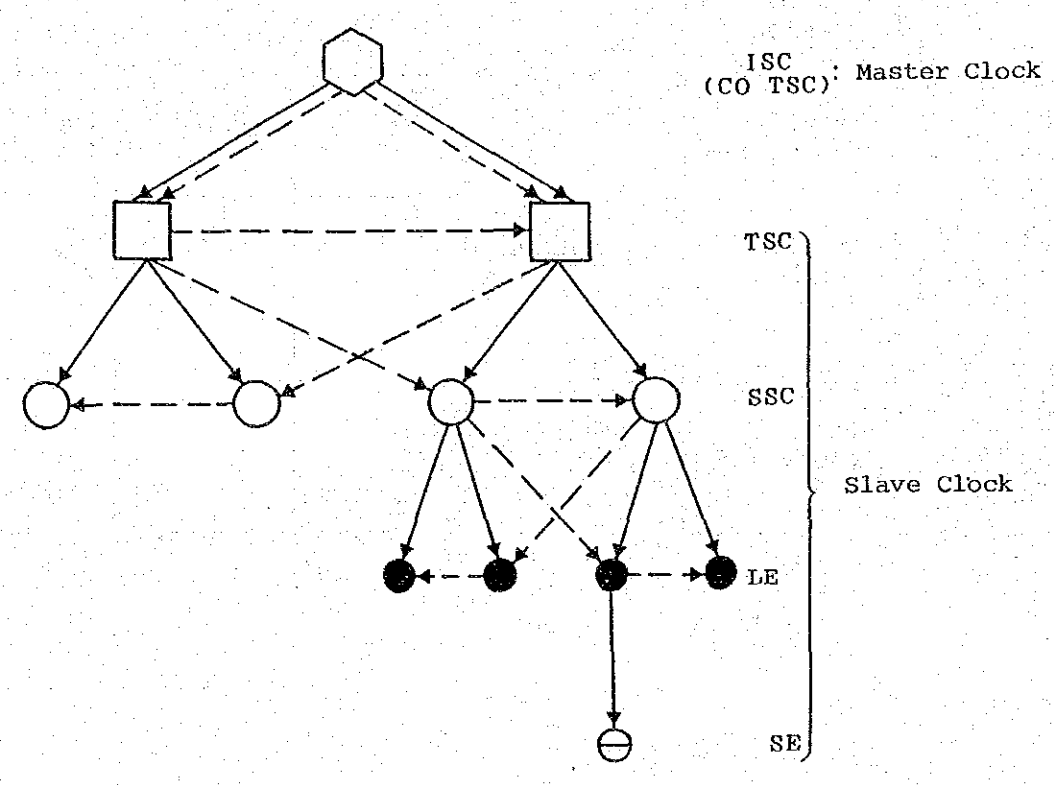
Based on other exchange clock source, home exchange frequency is controlled so that required oscillator precision can be 10^{-6} or thereabouts. Nevertheless, home exchange frequency control is by multiple loop system and this fact necessarily makes the whole network configuration complicated.

6.1.3 Master-slave synchronization

Required frequency precision can be 10^{-8} or thereabouts. Frequency control also is between master and slave exchanges only. Therefore, synchronization is relatively easy. When master exchange oscillator and distributor become faulty, slave exchange oscillator operates by itself and, where necessary, changes master oscillator to which it belongs, within allowable time limits.

6.2 National Network Synchronization Plan

In national network of Sri Lanka, master-slave synchronization system is adopted. International Switching Center (ISC) where caesium element oscillator is installed serves as master exchange. Following figure illustrates master exchange - slave exchange clock distribution in national network synchronization plan.



——→ denotes master exchange - slave exchange synchronization system

- - - → denotes alternative slave exchange synchronization system.

National Network Synchronization Plan

Table 5-13 presents specifications of currently adopted oscillators.

Table 5-13 Specifications of Currently Adopted Oscillators

Exchange Hierarchy	Type of Oscillator	Specifications		Life	Redundancy
		Stability	Precision		
ISC	Cesium Clock	-	$\pm 1 \times 10^{-11}$	3 years	Triplication
TSC (CNT)	Rubidium Clock	-	$\pm 1 \times 10^{-9}$	10 years	Duplication
TSC (KND, ANR GLE)	Quartz Clock (high accuracy)	$\pm 1 \times 10^{-9}$/day	$\pm 8 \times 10^{-8}$	20 years	Duplication
SSC LE SE	Quartz Clock	$\pm 1 \times 10^{-5}$/day	$\pm 3 \times 10^{-5}$	20 years	Duplication