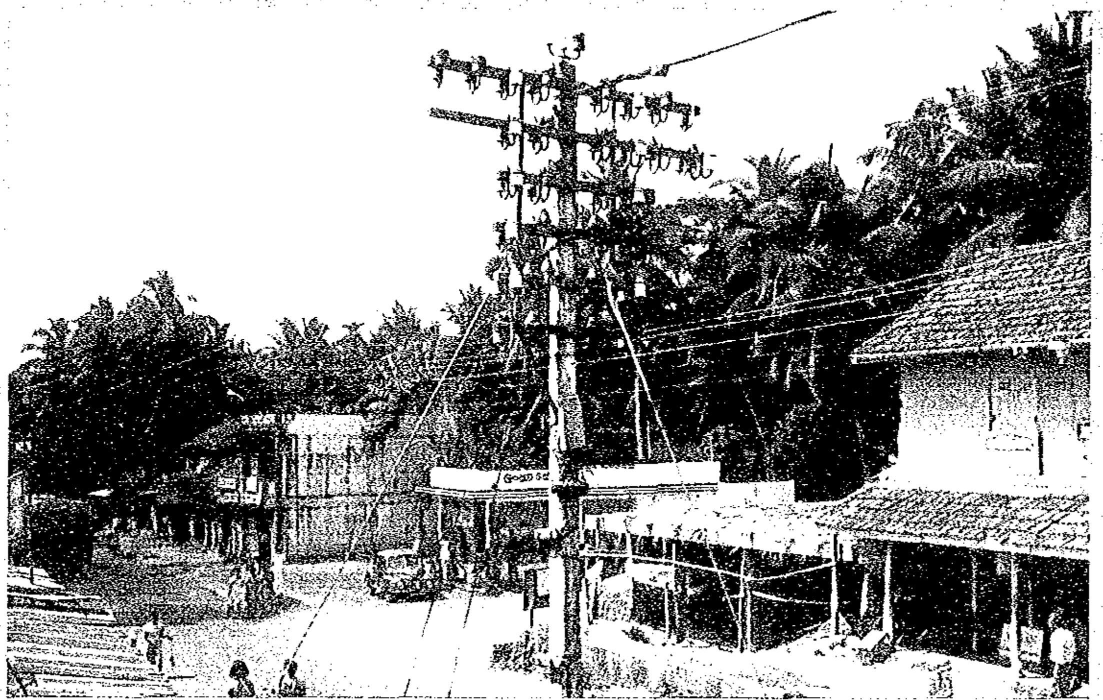
CHAPTER 6
EQUIPMENT PROVISION PRINCIPLES



Out Side Plant

CHAPTER 6 EQUIPMENT PROVISION PRINCIPLES

1. DEMAND FULFILLMENT PLAN

1.1 Motivation of Plan

For annual installation plan, the ideal is to so arrange the forecasted demand, as per Chapter 3, can be fulfilled 100% for each forecast year. Actually, physical restraints of various kinds including limitations on investment availability and installation capability make it difficult to realize 100% demand fulfillment in a short period.

The subject of study here is to coordinate all foreseeable restraints and formulate workable demand fulfillment plan up to the year 2000.

1.2 Demand Fulfillment Status Quo and Forecast for 2000

1.2.1 Status quo

Demand fulfillment rate on record at end of 1983 is 63.8%. Annual demand fulfillment records for the period from 1974 to 1983 are as under.

Table 6-1 Annual Demand Fulfillment Records, 1974 - 1983

	1974	1975	1976	1977	1978
No. of Installations (L.U.)	41,537	43,033	44,425	45,322	49,414
Demand Fulfillment Rate (%)	74.2	74.3	71.1	68.0	68.8

	1979	1980	1981	1982	1983
No. of Installations (L.U.)	53,600	61,194	63,878	65,905	73,425
Demand Fulfillment Rate (%)	69.7	79.1	71.1	70.0	68.3

Records show that in 1975 and 1980, with five years in between, large scale investment was made and demand fulfillment rate temporarily improved in each of those two years. However, in other years, the number of installations was small, lagging way behind the demand.

1.2.2 Forecast for 2000

Full demand fulfillment in a strict sense is unattainable. As stated in Chapter 3, when telephone density (number of telephones installed per population of 100) in the year 2000 is at a relatively low level of 5.6, demand is apt to emerge unexpectedly and tends to be scattered so that fully correct provision plan is difficult to make. When presumed from the situation in developed countries at the time the demand was at that level, demand fulfillment to the extent of 95% will be possible maximum.

Therefore, provision objective whereby to formulate reasonable installation plan is set at 95% for 1996 and 100% for 2000 whereas demand fulfillment objective is set at 90% for 1996 and 95% for 2000.

Demand fulfillment objectives, compared with installation objectives, for four forecast years are as under.

Table 6-2 Demand Fulfillment Objectives

	1986	1990	1996	2000
Demand Fulfillment Objective (%)	72	81	90	95
Provision Objective (%)	75	85	95	100

1.3 Additional Telephone Expansion

Additional telephone expansion based on the foregoing installation objectives are as under.

Table 6-3 Additional Telephone Installation

	1983	1986	1990	1996	2000
Total Number of Telephone Installed	73,425	119,340	261,670	553,210	1,080,570
Number of Additional Telephone Installations	-	45,915	142,330	291,540	527,360
Number of Telephones in Greater Colombo	46,468	75,130	164,830	348,570	680,900

2. SYSTEM SELECTION CRITERIA AND DESIGN PERIOD

2.1 System Selection for Digital Electronic Switches

Telephone switches to be newly installed in Sri Lanka from now forward are digital electronic switches. For existing analog switches, additional installation is for crossbar type only. For step-by-step type, no additional installation is scheduled.

Digital electronic switches are featured in, among other things, the way the host exchange and remote switching unit (RSU) operate. Taken up for study here are operation standards for host exchange and RSU.

2.1.1 Economic comparison

Usually, RSU is remote-controlled by central processor of host exchange. All calls including calls within RSU area, calls to host exchange area and toll calls are sent to host exchange for switching. When host exchange fails to work normally due to power failure or system trouble, for instance, calls within RSU area only are switched by local processor of RSU. (In this case, RSU is to be provided with stand-alone facilities.)

Which, host exchange or RSU, to use for switching depends upon the required cost of processing per call. Cost comparison is by

$$F_H = C_{HI} + C_{HC}$$

$$F_R = C_{RI} + C_{RC}(1 + \beta) + \alpha \cdot C_{HI} + C_{HC} + C_X \cdot M(1 + \beta)$$

$$\alpha = \frac{T_R}{T_H + T_R}$$

where

F_H: Required cost of processing per call at host exchange

F_R: Required cost of processing per call at RSU

C_{HI}: Initial investment in terms of call for host exchange

C_{HC}: Connection cost in terms of call for host exchange

C_{RI}: Initial investment in terms of call for RSU

C_{RC}: Connection cost in terms of call for RSU

α: RSU terminal ratio to host terminal

C_X: Transmission cost per km

M: Distance between host exchange and RSU

β: Local call ratio

Using as parameters the value of M, value of α and value of β whereby $F_H = F_R$ holds true, optimum solution is to be obtained.

C_{HC} and C_{RC} represent per call equivalent of system operation cost so that both are extremely small compared with other parameters. Here, they are omissible.

Therefore, $F_H = F_R$ can be substituted by

$$C_{HI}(1 - \alpha) - C_{RI} = C_X \cdot M(1 + \beta)$$

That is to say, when construction investment balance between host exchange and RSU is smaller than transmission route cost, independent exchange should be adopted. In the contrary case, adoption of RSU is advantageous.

In JICA F/S Report on Greater Colombo Project of November 1983, C_X is 2.05 million Rupees/km.

For C_{HI} and C_{RI}, the following numerical data can be obtained from study of Sri Lanka project contract already in effect:

Host Exchange Terminals	RSU	RSU Branching Point
5,000	200 (α = 0.04)	(β = 0.2) 11.2 km
5,000	200 (α = 0.04)	(β = 0.4) 9.6 km
5,000	450 (α = 0.09)	(β = 0.2) 10.3 km
5,000	450 (α = 0.09)	(β = 0.4) 8.8 km
10,000	200 (α = 0.02)	(β = 0.2) 23.6 km
10,000	200 (α = 0.02)	(β = 0.4) 20.2 km
10,000	450 (α = 0.045)	(β = 0.2) 22.3 km
10,000	450 (α = 0.045)	(β = 0.4) 19.1 km

The foregoing finding can be graphically presented as under.

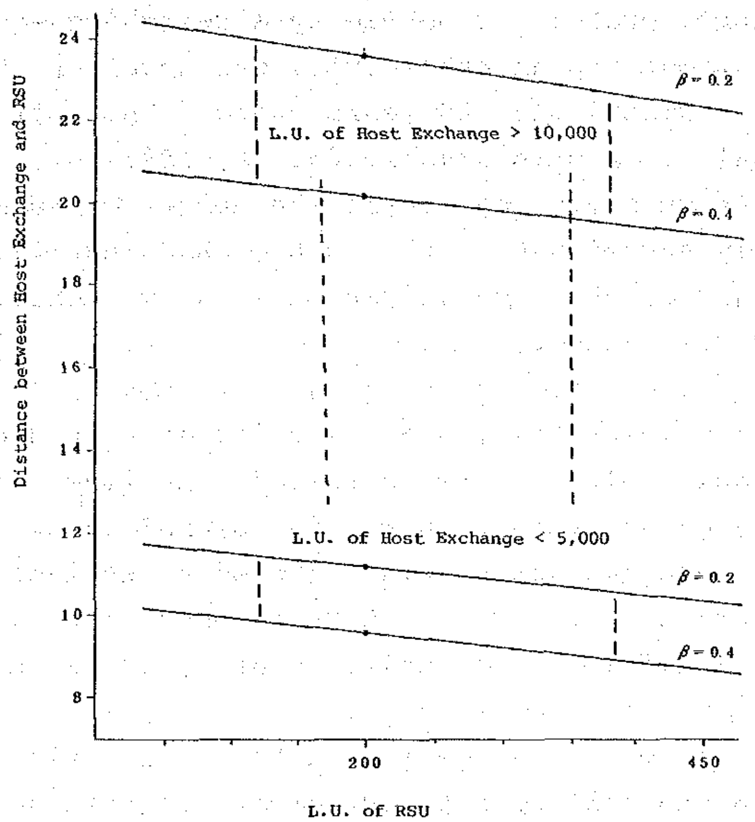


Figure 6-1 Economic Comparison for Selection of Switches

For the lower part of tendency curve with approximate conditions to the preceding illustration, RSU is preferable economically. So are independent exchange for the upper part of the curve.

In Sri Lanka, host exchange - RSU distance is about 20 km in average. When host exchange terminals number 10,000 or thereabouts, RSU terminals can be not more than 450 or so in order to maintain economical network formation. However, when host exchange terminals number less than 10,000, the distance to RSU should preferably be as short as possible.

2.1.2 Selection by number of terminals

Mechanical life of switching equipment is 20 years. Therefore, except for mobile type switching equipment, actual project plan takes into consideration the possible demand size 20 years ahead. The unit number of terminals at RSU is usually 64, 96, 128, 192, 256 or 512. At such exchange where the number of terminals may possibly exceed 500 in the future, RSU installation is temporary so that, by reason of economy, mobile type RSU should be adopted.

Greater Colombo Area, several units of E-10 digital electronic switches are installed. Maximum call processing capacity of E-10 ESS is assumed to be 190,000 BHCA. When average holding time of calls including ineffective calls is set at 90 seconds, maximum processed traffic can be estimated at 3,800 Erlang.

Therefore, when average subscriber originating/terminating calling rate is set at 0.16 Erlang, E-10 B system can accommodate in one unit a maximum of 23,000 subscribers in the sum of host exchange subscribers and RSU subscribers. Actually, however, from the viewpoint of facilitating system maintenance and operation on one hand while, on the other, minimizing influence of troubles due to host exchange - RSU control circuit failure, for instance, the number of terminals at one RSU is to be limited to a maximum of 5,000. In case where greater RSU capacity is considered to be necessary, an independent exchange is to be designed to accommodate own RSU and another subscribers.

2.2 Subscriber Carrier System Application

Today, in Sri Lanka, no-telephone area does not exist. Telephone service to remote subscribers in distant area from exchange is by open wire carrier system.

MAS (multi-access subscriber radio system) is also introduced, but in a few and special cases only.

With a view to stable system architecture by means of full digitalization as final objective, the existing unstable open wire carrier system should be abolished gradually and replaced with digital new system.

In Sri Lanka, the number of remote subscribers is large. Common patterns among them are:

(1) In many cases, remote subscribers are accommodated in small sized switchboards at villages, each more than 10 km distant from Secondary Switching Center (SSC). Meanwhile, those outdated analog switchboards are scheduled to be replaced sooner or later in preparation for digitalization.

(2) After small sized analog switchboards are withdrawn, distance to subscribers becomes consequently more than 10 km from the host exchange. Therefore, line loss exceeds the standard value even if maximum conductor diameter cable or telephone set specially designed for high loss subscribers is used.

(3) Because cable route by open wire exists, pole route wiring to new subscribers from now also is possible.

(4) For some time to come (3 to 5 years), the number of subscribers will be in the neighborhood of 30.

To relieve those remote subscribers, system making should proceed step by step in accordance with demand trend in each area concerned. In the period when the number of subscribers is relatively small at 20 or thereabouts, system making should begin with subscriber carrier system or, if need be, subscriber radio system.

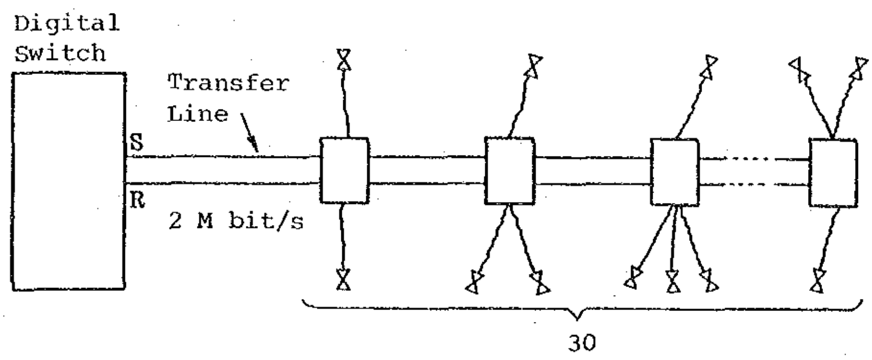
As the number of subscribers continues to increase, showing signs to reach a level of 100, system making methodology transfers to establishing RSU (remote switching unit) at demand center and using existing transfer lines as trunk lines.

2.2.1 Digital subscriber carrier system

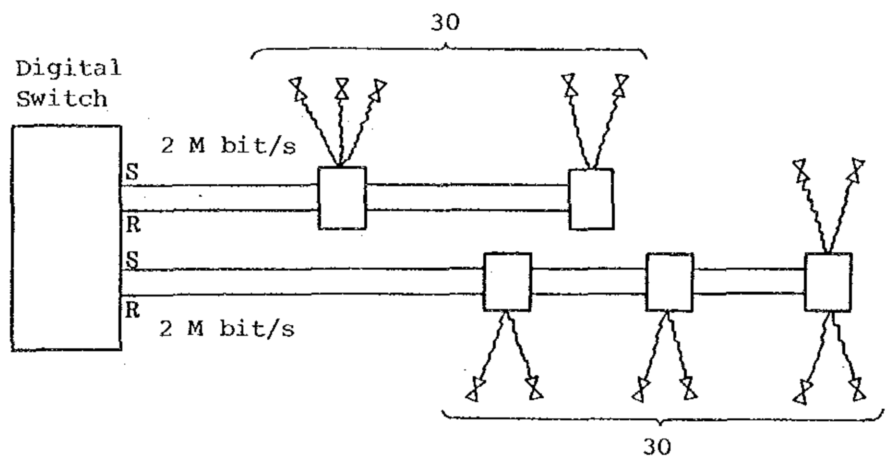
In the Digital Subscriber Carrier System, subscribers are connected to remote line multiplex (R.L.M). Each R.L.M. uses time division multiplexing to convert the signals from subscribers into a 2-Mbit/s digital signal. The R.L.M. have drop and insert capability for the 2-Mbit/s digital signals. This means the R.L.M. can be connected in series by means of metallic lines laid along the road, increasing the number of subscribers accommodated up to 30. Each R.L.M. can also serve to concentrate subscriber lines. So if the number of subscribers should rise above 30 in the future, they can be concentrated and accommodated in this system. The 2-Mbit/s signal is sent to the local exchange by way of the transfer line.

At the local exchange, the central office terminal receives the 2-Mbit/s digital signal from the remote terminals. This central office terminal serves as a digital interface to the switching equipment.

System block diagram appears in Figure 6-2.



(1) Less than 30 subscribers



(2) More than 30 subscribers

Figure 6-2 System Block Diagram

2.2.2 Subscriber radio system

Subscriber radio system development at the present stage is mainly on digital basis, using TDMA technology. System now in use can interface with both digital and analog switches and can make trunk connections in radio section also. The system can even accommodate 50 km or more distant subscribers.

However, subscriber radio system requires radio transmitter-receiver, antenna and simple-build tower. This fact makes system cost relatively high.

In this report, subscriber radio system application is restricted to these cases only:

(i) To accommodate subscribers in isolated islands as in Jaffna Secondary Switching Center area;

(ii) To accommodate subscribers in such area where cable installation is difficult geographically.

For frequency bands, 800 MHz and 1.5 GHz bands are mainly used in digital system. To be noted is that 800 MHz band is commonly used for mobile radiotelephone service in all parts of the world so that, in Sri Lanka also, 800 MHz band is to be reserved for mobile radiotelephone service to be introduced some time in the future. Thus, for subscriber radio system, use of 1.5 GHz band is recommendable.

Figure 6-3 presents system application diagram for remote subscribers.

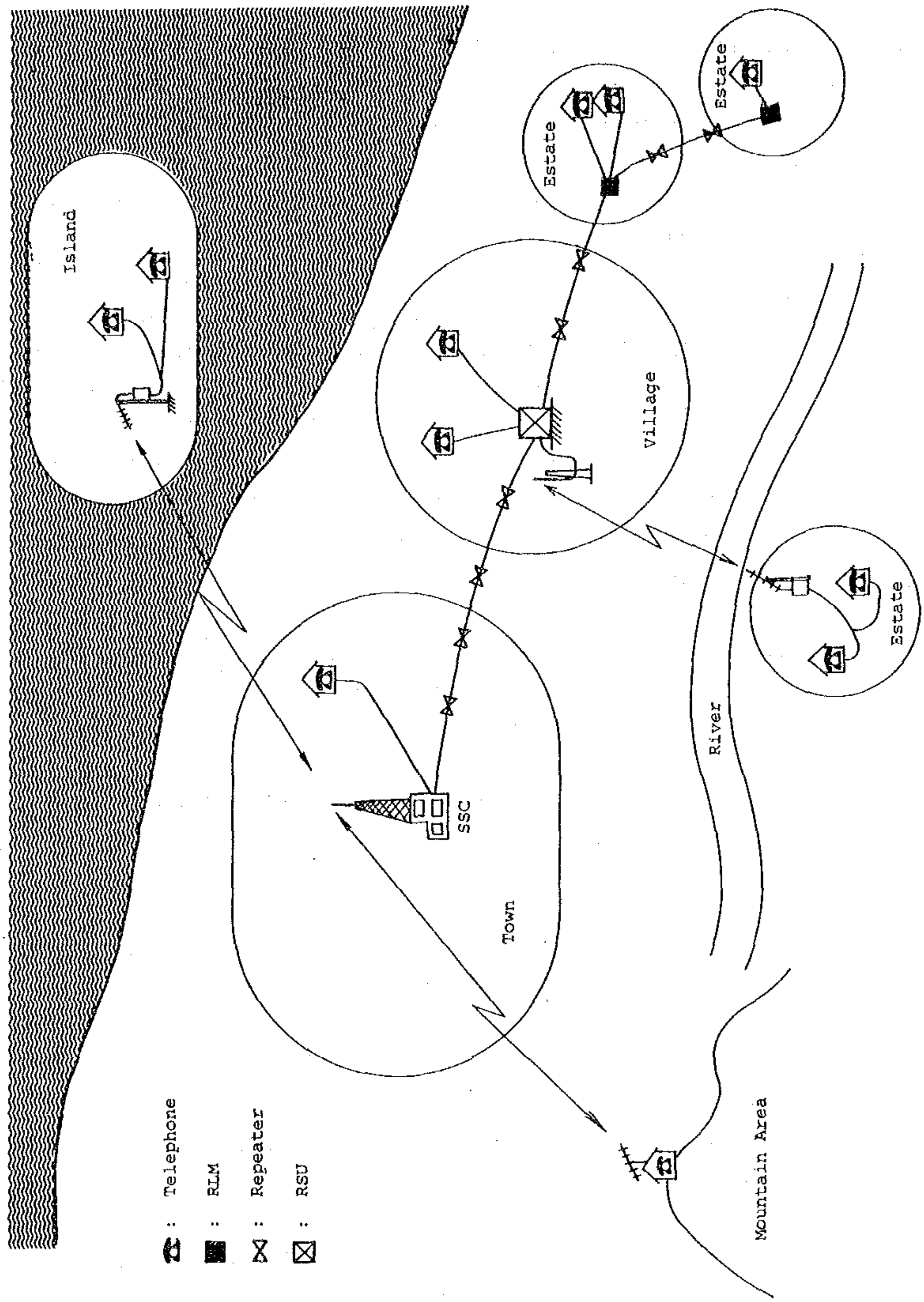


Figure 6-3 System Application Diagram for Remote Subscribers

2.3 Transmission Route and system selection

2.3.1 Transmission route selection

Items to be considered in transmission route selection are as under.

(1) Generally, transmission route construction cost increases in proportion to route distance. Hence the selection of as short route as possible.

(2) To economize construction cost and facilitate maintenance and operation, repeater sites be selected in the neighborhood of public roads as far as possible.

(3) For purpose of transmission route reliability improvement in the future, selection be made for route where diversifying is possible.

(4) Especially for radio route, moist land or oversea section be avoided by reason of adverse influence on radio propagation characteristics.

For actual route selection, in-depth field survey in addition to the foregoing requirements is necessary. Radio repeater site selection places emphasis on repeater spacing and access road length. This is because, in Sri Lanka, roads are generally well maintained and power supply is available at almost all places, posing problem in no respect.

For radio system, maximum number of connections between TSC and SSC should be limited seven and maximum route length should be limited 250 km or thereabouts to keep the same grade as existing transmission performance.

In this master plan, diversifying of total network is not considered. However, on particular section where large circuits are concentrated such kind of circuit formation is not desirable from the viewpoint of whole network reliability. For, failure in one section sometimes exerts fatal impact on network performance as a whole. Thus, in this Master Plan, route diversity is introduced for such cases to improve route performance reliability.

2.3.2 Transmission system selection

Transmission systems now in use for Trunk and Junction routes are:

o Trunk routes

(a) 4 GHz band, 68 M bit/s system

(b) 8 GHz band, 68 M bit/s system

(c) 2 GHz band, 34 M bit/s system

(d) 2 GHz band, 17 M bit/s system

(e) 34 M bit/s optical fiber system (for entrance to exchange)

(f) Cable PCM system (for entrance to exchange)

o Junction routes

(a) 2 GHz band, 34 M bit/s system

(b) 2 GHz band, 17 M bit/s system

(c) 2 GHz band, 4 M bit/s system

(d) Cable PCM system

For transmission system expansion plan, following method should be considered. Existing routes will be expanded up to system capacity limits. For new route establishment and new system introduction, selection will be made, based on estimated circuit requirement as of the year system life. In this case, applied system should be selected among systems already adopted, in consideration of standardization of spare parts, measuring equipment, maintenance/ operating practices and personal training method.

Maximum capacity of existing transmission system is 68 M bit/s (equivalent to 960 telephone channels). On transmission route where large transmission capacity (34 M bit/s x 8 systems or more) is required from now forward, 140 M bit/s (equivalent to 1920 telephone channels) system will be required. For radio system, 16 QAM (Quadruple Amplitude Modulation) technique is adopted to realize the bit rate of 140 M bit/s. At present, to ensure its system characteristics, space diversity and automatic equalization functions are essential for each section. This means higher cost than in the case of transmission system wherein other modulation system is used.

Circuit requirement up to the year 2000 can be fully satisfied by use of 4 GHz band and 8 GHz band so that in this Master Plan, 16 QAM system introduction is not considered. As for optical fiber system, short distance transmission by short wavelength band fiber cable constitutes common practice. This time, however, in view of worldwide development trend and in consideration of possible application for long distance transmission, long wavelength band (1.3 μm) fiber cable will be used.

In the almost all existing routes, existing system capacity can satisfy circuit requirement up to the year 2000. However, in the section where circuit requirement exceeding existing system capacity is foreseen, new system will be introduced side by side with existing system or route diversity will be adopted to disperse circuits. For radio system, in such cases, radio interference will be subject so that, full prior study about interference will be required to avoid interference to/from surrounding systems.

Cable PCM system application to trunk route has hitherto be an expedient for cable entrance from radio repeater station to telephone exchange. This principle is adhered to in this Master Plan also.

For junction route, cable PCM system is adopted basically. Radio system is for cases where cable installation is difficult topographically and where transmission distance is long.

As for 2 GHz band radio system, transmission capacity is small (maximum 6 systems) and interference probability in the same system is also high. Therefore, preference is for adopting large capacity system and, at the same time, reducing the number of systems to be established to possible minimum.

In this Master Plan, 17 M bit/s system is the standard system.

Because 2 GHz band system is subject to heavy radio interference in the same system, new/additional system construction requires full prior study about interference. CCIR recommends four frequency bands that quality for 2 GHz band system. (Refer to CCIR Rec.

283-4) which of those four bands to use depends upon findings in interference study.

2.4 System Design Period

For telecommunications network expansion, the most economical expansion methodology must be considered. From this viewpoint, (1) system design period and (2) scale of expansion must be determined.

2.4.1 System design period

The ideal is to determine optimum investment period (system design period) for each applicable technology and for each equipment type by means of economic comparison as described in CCITT Local Network Planning, Geneva 1979, Economic Period Provision.

However, in the countries like Sri Lanka where large scale expansion projects have to be financed with funds from overseas sources, system design period and equipment type to be adopted vary from one fund supplier country to another. This fact makes it extremely difficult to establish ideal work cycle.

In many cases, telecommunications projects require at least three years for installation work. This means that unless four or more years elapse after project implementation gets underway, service revenue from the system concerned cannot be expected. In other words, when optimum installation period determined by economic comparison is within four years, installation work is to be initiated during installation. This is not practical.

This time, installation period is to be five years, in principle, without distinction by equipment types. Exception is in the case of outside plants. That is to say, in consideration of legal restrictions imposed upon road excavations, installation period is to be 8 - 10 years.

2.4.2 Expansion work scale

Basic expansion work scale is given in Figure 6-4 (A). Desirable work format is that all existing facilities be mobilized in the next expansion period (five years) and all expansion facilities come into service without delay. However, if actual demand exceeds forecasted demand in the period wherein demand and supply must be balanced and if the method to meet excess demand is by having expansion facilities come into service when the working facilities are at the limits of their capacity, there arises a period wherein supply lags behind demand. (Refer to Figure 6-4 (B).) For this reason, expansion work should have spare capacity so that it can successfully respond to demand fluctuations. (Figure 6-4 (C))

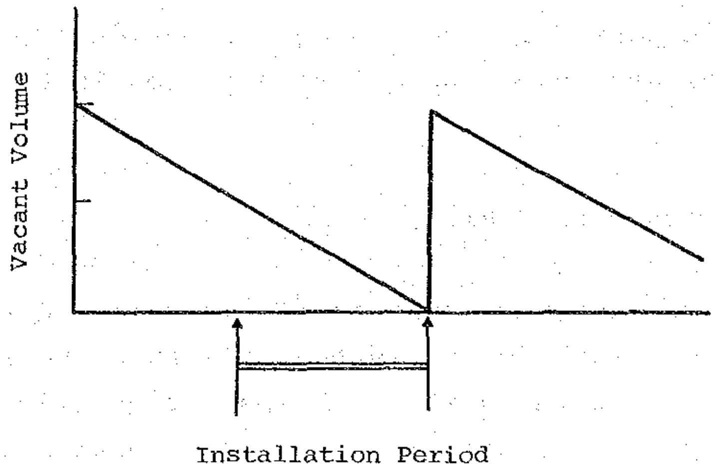


Figure 6-4 (A) Basic Expansion Work Period

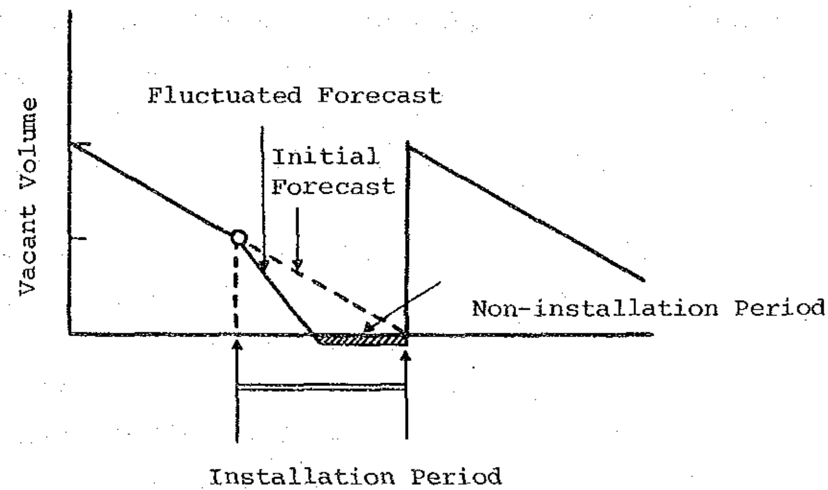


Figure 6-4 (B) Installation Void due to Demand Fluctuation

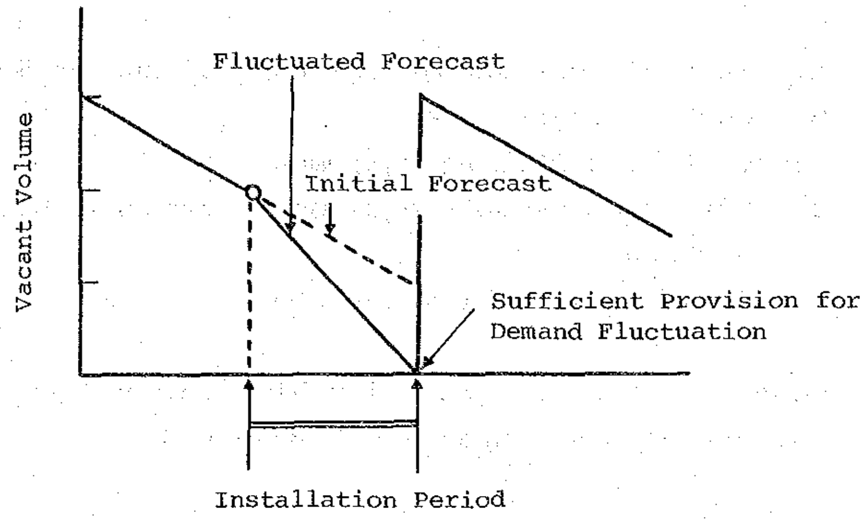


Figure 6-4 (C) Installation with Spare Terminals Adopted

Figure 6-4 Installation Period Considered with Demand Fluctuation

3. EXCHANGE SIZE DECISION

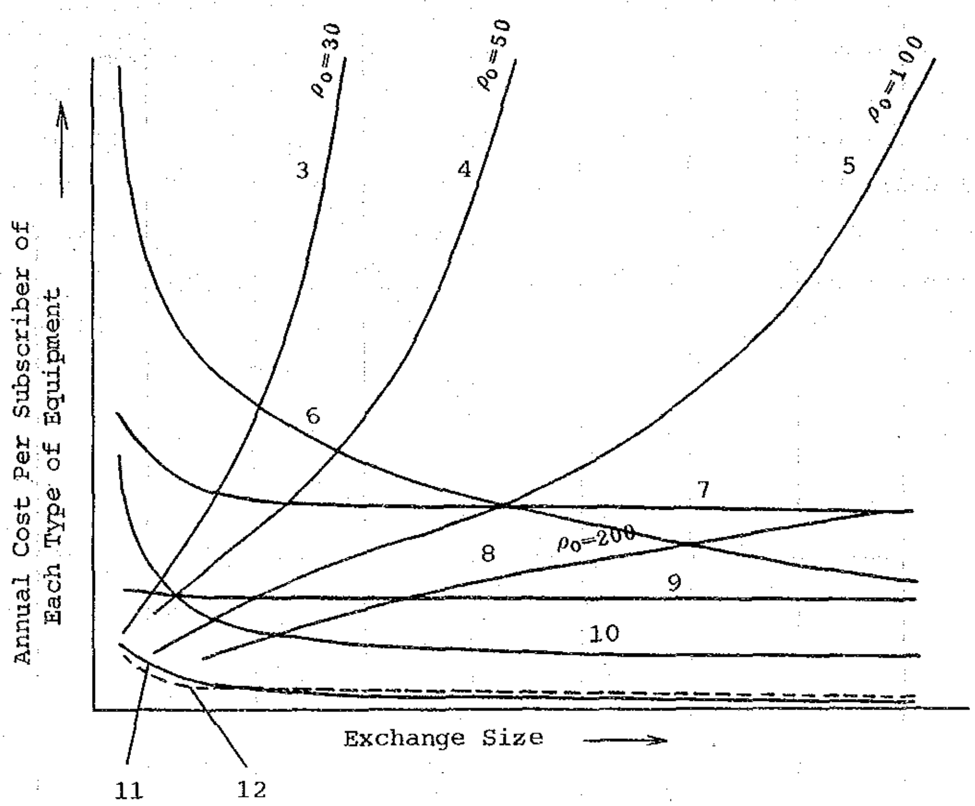
for decision of appropriate exchange size, decision of the following items by economic comparison is essential:

a. Initial cost and annual cost of subscriber's line
b. Cost of trunk line
c. Cost of switching equipment
d. Cost power supply equipment, exchange building and exchange site
e. Cost of system maintenance

Generally accepted relationships between exchange size and annual cost appear in Figure 6-5.

In Figure 6-5, ρ_o denotes subscriber demand density (number of subscribers/ha). In the case of branch exchange in multi-exchange area, for instance, subscribers in exchange area are considered to be almost equally distributed so that ρ_o may well be expressed by number of subscribers/ha.

Relationship between exchange size and length of one side of exchange area in case where unit amount adopted in Sri Lanka is applied is graphically presented in Figure 6-6.



1. Annual cost per subscriber of each type of equipment
2. Exchange size (unit: 10,000 terminals)
3. Annual cost of subscriber's line (Po = 30)
4. Annual cost of subscriber's line (Po = 50)
5. Annual cost of subscriber's line (Po = 100)
6. Cost of maintenance staff for machines
7. Annual cost of machines
8. Annual cost of subscriber's line (Po = 200)
9. Annual cost of trunk line
10. Annual cost of exchange building
11. Annual cost of exchange site (solid line)
12. Annual cost of electric power (dotted line)

Figure 6-5 Annual Cost per Subscriber by Exchange Size

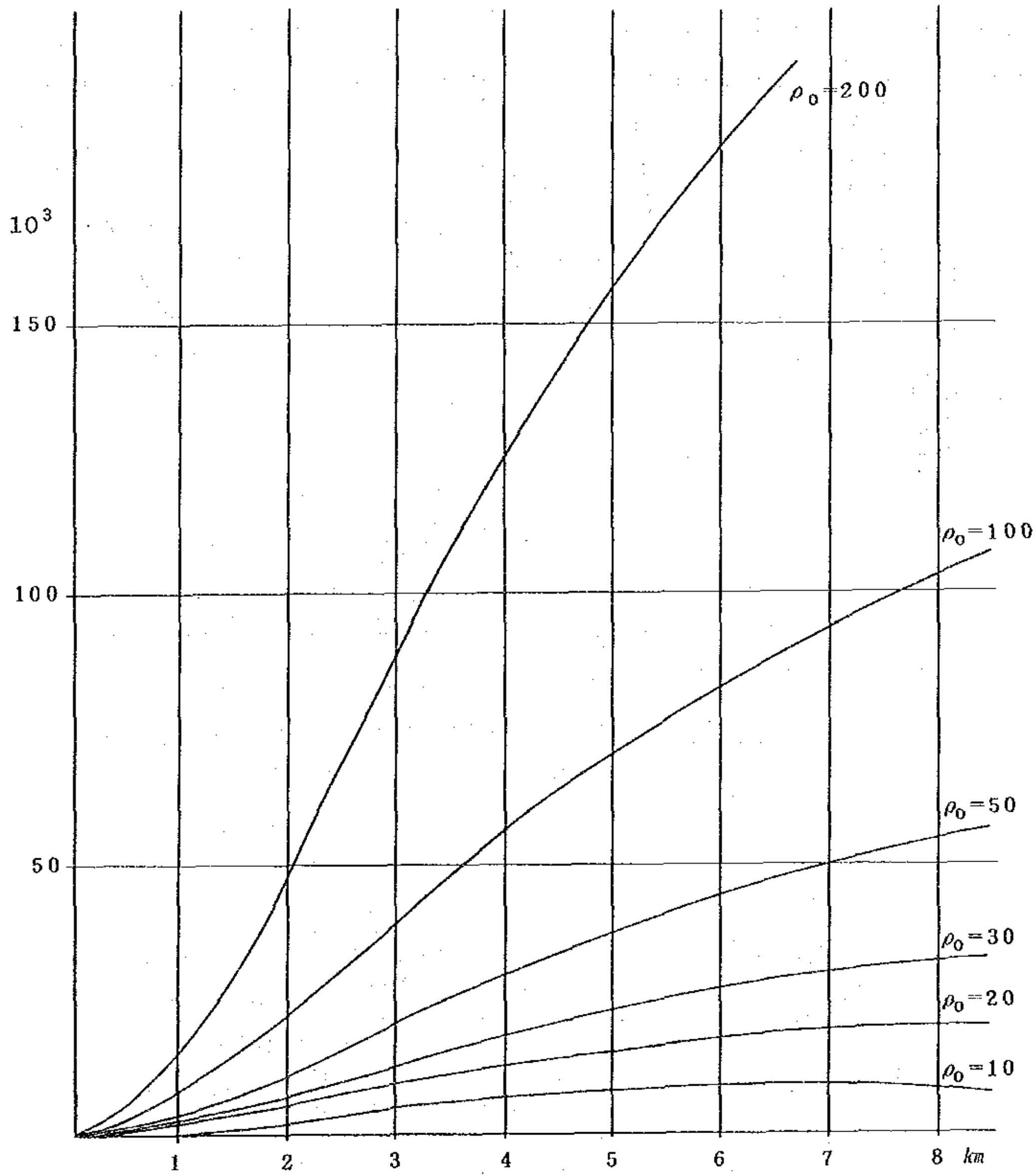


Figure 6-6 Optimum Exchange Size and Length of One Side of Exchange Area

Figure 6-6 indicates that at local exchange, ρ_o is extremely low so that local exchange even as single exchange can pay economically, whatever the length of one side of exchange area. Contrarily, at Colombo Central, ρ_o is as high as 130 because the forecasted demand as of the year 2000 is about 150 thousand while the exchange area covers 1,156 ha. Thus, for Colombo Central, optimum exchange size considering the present 3.5 km square exchange area is of 70,000 terminals. At least two exchanges are to be required by year 2000.

4. EQUIPMENT REPLACEMENT/TRANSFER

4.1 Equipment Life

Equipment life is divided into several kinds. One differs from another in the assessment of factor that terminates equipment life and the method whereby equipment life is measured. Representative kinds are as under.

a. Physical life

Physical life means a period wherein equipment installed is used normally and, due to wear and tear that naturally take place, finally becomes useless.

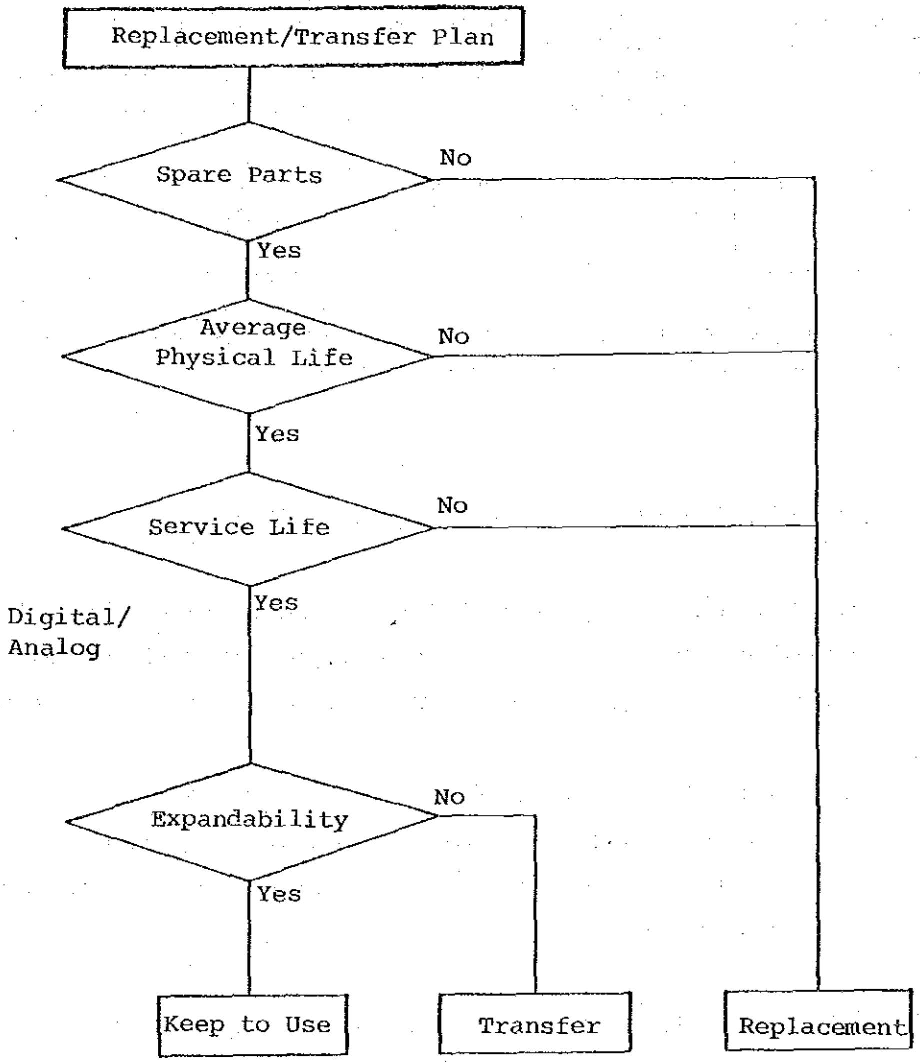
b. Service life

Service life means a period wherein equipment installed actually remains in use, whatever the factor that terminates its life. In many cases, service life is determined by functional capability of equipment.

c. Economic life

Economic life means a period wherein annual cost inthe sum of invested capital recovery cost and annual maintenance and operation cost is at minimum level.

In the countries like Sri Lanka where equipment supply is almost wholly from other countries, restrictions on availability of maintenance parts and components exert adverse influence on physical life of equipment. Furthermore, because of rapid technological renovation, equipment functions become outdated faster than expected, causing service life to be degraded a great deal in many cases. Shown below is a flow chart of equipment life philosophy as an instrumentality to equipment consolidation plan.



Average physical life and economic life vary according to equipment type. Empirical values are given in Table 6-4.

Table 6-4 Physical Life and Economic Life Mean Values (Empirical Values)

Equipment	Equipment Type	Life	Remarks
Switches	Crossbar switches Digital switches Power supply equipment	18 years 20 years 12 years	
Outside Plant, Cable	Outside plant Local cable Toll cable	25 years 10 years 15 years	* Aerial cable system Aerial cable system
Transmission, Radio	Transmission equipment Radio equipment	12 years 10 years	

* In the case of duct cable or direct buried cable system, life is longer than mentioned in the table above.

4.2 Practical Equipment Replacement/Transfer

For practical equipment replacement/transfer plan, decision is made by principles described below. The state of things in Sri Lanka also is duly considered.

(1) When physical life reaches its limits, equipment concerned is disused. Parts and components of such equipment are re-used as spare parts and components for equipment of the same type.

(2) Considering service life, equipment concerned (mainly switches) is transferred to such places where the equipment is relatively free from functional troubles.

For transmission and radio equipment, such transfer is not considered because physical life is short. For analog equipment also, expansion is not carried out, in principle.

XB switching equipment is to be used up to their physical life even service life reaches.

Consolidation (re-use and disuse) plan for switches appears in CHAPER 7, Table 7-4.

5. MAINTENANCE AND OPERATION PLAN

For maintenance and operation of telecommunications systems which are being rapidly expanded, careful consideration is required about the items mentioned below.

5.1 Manpower Plan

The number of telephones installed in Sri Lanka (including extension telephones) at end of 1984 was estimated at 88,000. Against this number of telephones, the number of staff SLTD personnel at end of 1984 is estimated at 10,000. This estimate is from the corresponding number of 9,549 at end of 1982. And, in 1982, up to 8,065 out of the total of 9,549 were on technical staff in charge of planning, maintenance and operation.

For 1984, productivity (number of telephones per SLTD person) of SLTD is 9. This rate is too low, compared with neighboring countries. Especially so when it is considered that SLTD is a government organization and is obligated to promote employment.

Table 6-5 Telephone Maintenance Rate per Staff (in terms of telephone set)

Indonesia	Thailand	Japan
27	*47	**32

Note: * Telephone division only
** For 1961.
Telephone density: 6.7 sets/100 inhabitants

Telecommunications equipment to be newly introduced from now forward are of high reliability and operation jobs will become to be almost completely automatic. For this reason, the present low productivity of SLTD can be expected to improve to somewhere around 50 telephones per person. Following is the recommended manpower plan for attaining such objective:

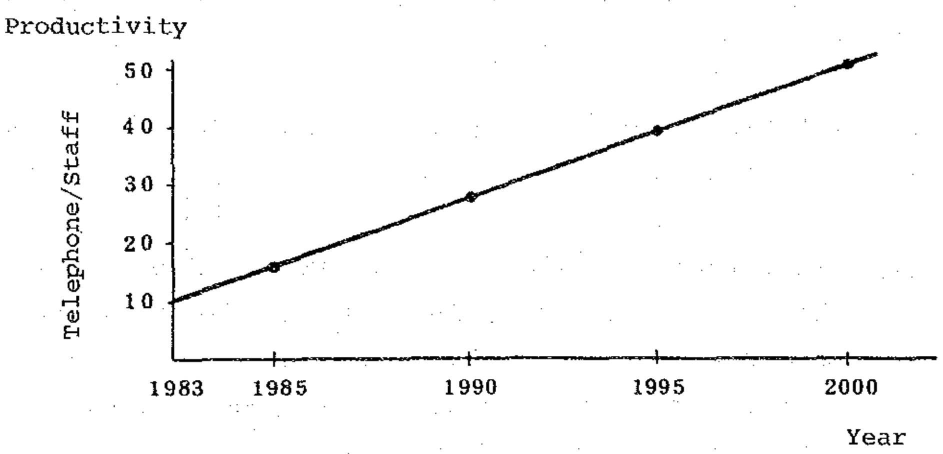


Figure 6-7 Productivity of SLTD

Table 6-6 Manpower Plan by Year

Year	Telephone Maintenance Rate (set)	Total Telephone Installation Estimate	Total No. of SLTD Personnel	New Employment
1986	15.0	119,340	7,956	-
1990	25.0	261,670	10,570	570
1996	37.5	553,210	14,800	4,230
2000	50.0	1,080,570	21,600	6,800

5.2 Maintenance and Operation Organization

For maintenance and operation organization, the existing organization will be maintained, in principle. That is to say, the whole organization will be composed of SLTD headquarters organization and four regional organizations at Colombo, Kandy, Galle and Anuradapura. Organizational chart of Kandy Area Maintenance and Operation Organization as typical example of regional organization is in Figure 6-8.

The existing organization is somewhat defective in functional aspect. More precisely:

(1) Analytical studies are not always done completely. Analytical study deals with traffic measurement, measurement and analysis of various reference values of connections, as well as trouble statistics making and analysis, and, as such, is essential for ensuring desirable service quality.

(2) Maintenance and operation manuals standardized by SLTD for use in all parts of the country are not available. Maintenance and operation are being carried out by equipment manufacturers' instruction manuals or by experience of individual persons in charge.

(3) For all kinds of records to be prepared and preserved by each component unit of the organization and for reports and other documents from lower units to high echelons of the organization, no standardized format is available. Nor are the relevant rules unambiguously established. For this reason, the organization's higher management is in no position to know where problems lie and how to cope with them.

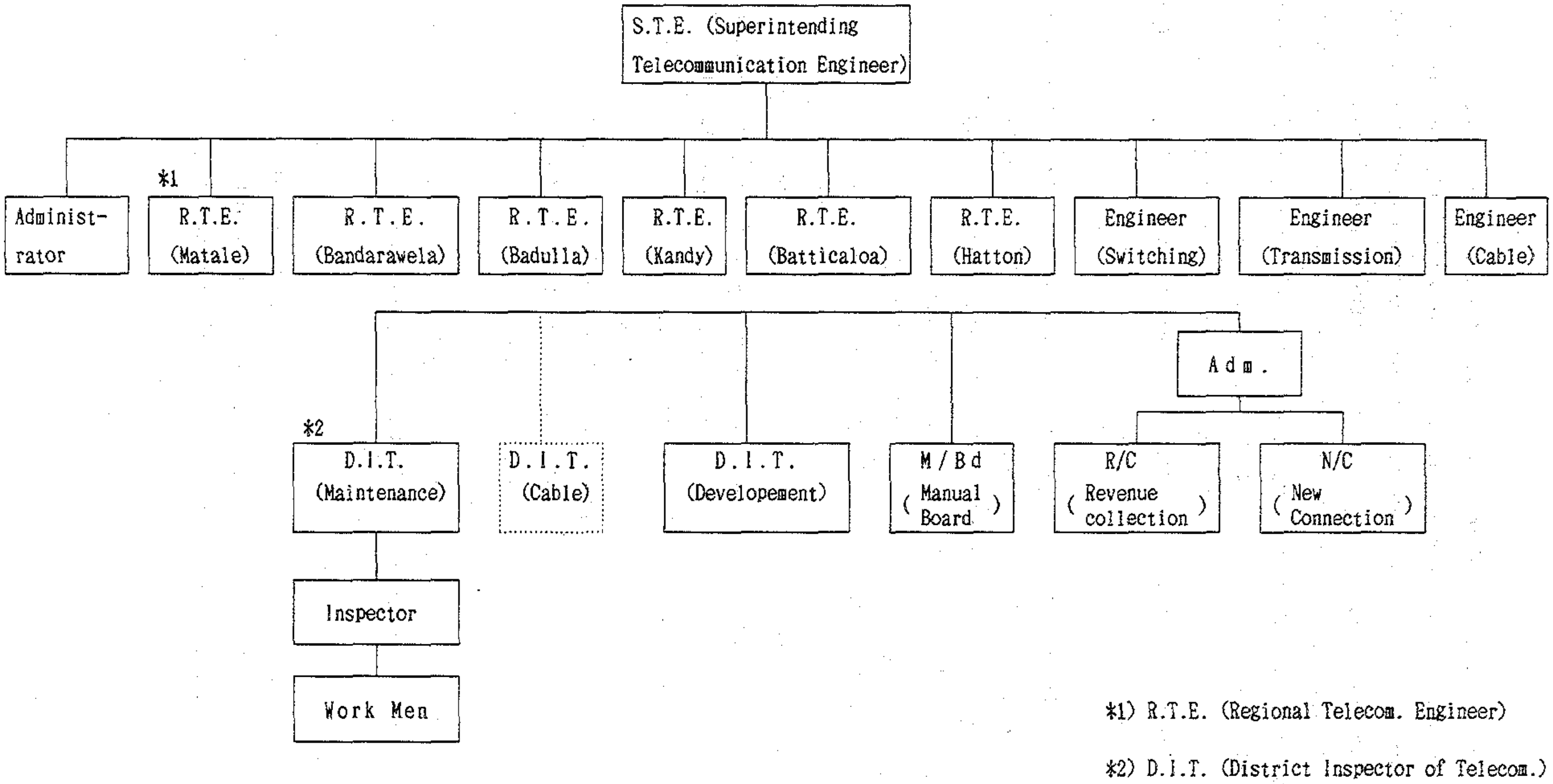


Figure 6-8 Kandy Area Maintenance/Operation Organization

To eliminate the foregoing defects and accomplish functional improvement of the organization, recommendations are made as under. Meanwhile, to observe these recommendations, manpower recruitment and financial investment for procurement of necessary equipment are required so that in-depth ad hoc proposal will be made in the latter part of this report.

A. To establish Maintenance Center (hereafter referred to as MC) at each TSC

MC directly belongs to S.T.E. of regional organization and ranks the same as R.T.E. (Refer to Figure 6-8: Kandy Area Maintenance and Operation Organization.)

MC performs these duty items:

a. To make periodical traffic measurement and measure various reference values of connections (successful call rate, grade of service by route, etc.) for each exchange.

b. To compile measurement results statistically and analyze them; to make trouble statistics by exchange and analyze causes of troubles.

c. To keep maintenance spare parts and components in custody by bulk and carry out inventory adjustment.

d. To report periodically and as occasion calls the results of items a. to item c. above to the competent organization faculty.

e. To keep exchange by exchange plant records in good order so that they can be referred to whenever necessary.

B. To introduce small sized electronic computers

Small sized electronic computers fit for work contents are to be introduced at each exchange, MC and component units of the organization whereby to mechanize work performance and raise work efficiency.

Work items to be computerized at each exchange are:

a. Subscriber records (names, directory numbers, addresses, cable pair number list, trouble records, etc.)

b. Recording of traffic measurement results.

c. Recording of reference values of connections (holding time, number of ineffective calls, circuit busy measurement by route, etc.)

d. Others

Data stored in small sized electronic computer at each exchange is transmitted to MC at each TSC by digital transmission circuit. Electronic computer at MC is used for fulfillment of previously mentioned MC duty items. Results are transmitted to SLTD Headquarters from each MC.

Electronic computer at SLTD Headquarters is required to process and store data supplied by each MC.

C. To institute maintenance and operation standard practices

a. Decision of operation management limit value

Although 100% elimination of troubles at each equipment is unrealizable, trouble rate reduction is possible if considerable time and money are spent. In this case, cost necessarily increases. Therefore, allowable trouble limit is set for each equipment and service category and such limit value is used as operation management objective.

b. Standard practices

(i) Preventive maintenance

As in the case of operation management limit, periodical maintenance cycle is determined and practiced for each equipment category.

(ii) Ex post facto maintenance

Ex post facto maintenance is for trouble ridden equipment or for equipment already beyond operation management limit. Maintenance procedures have to be determined in advance.

c. Standardization of report format and reporting procedures

Report format is standardized so that same reporting by the same procedures at all times will be possible. Purpose is to facilitate correct operation and maintenance management.

For practicing of the foregoing improvement plans, further in-depth study is necessary. Actual plan formulation by maintenance and management expert group is recommendable.

5.3 Maintenance and Operation Manpower Arrangement for Local Exchange

At local exchange where RSU installed is of less than 1,000 terminals, maintenance and operation staff is unattended, in principle. Maintenance and operation of such local exchange are to be by higher ranking SSC. However, in case where local exchange is located more than 30 km distant from SSC so that SSC maintenance staff requires more than one hour to proceed, even by car, to local exchange when it is trouble ridden, 2 to 3 maintenance and operation personnel (to assume duty by shift) will be assigned at local exchange.

5.4 Training

Maintenance and operation staff members receive training at Sri Lanka Telecommunications Training Center. Curricula consist of classroom lectures and on-the-job training. Furthermore, they should be provided with opportunities for positive participation in overseas training courses sponsored by equipment manufacturer/supplier.

6. AUXILIARY FACILITIES CRITERIA

Auxiliary telecommunications facilities must be proportional to main telecommunications facilities which are being rapidly expanded. Proposals concerning auxiliary facilities provisioning philosophy are made hereunder.

6.1 Definition of Auxiliary Facilities

Auxiliary facilities mean such facilities that support main telecommunications facilities expansion or are prerequisite to maintenance and operation of main facilities. Welfare facilities for SLTD employees, for instance, are not included in auxiliary facilities mentioned here. Facilities that come under category of auxiliary facilities are as under.

- Equipment and materials depot

  This facility does not include storehouses for temporary storage for big project.

- Lineman center

  This facility includes offices for staff linemen and warehouse for outside plant materials.

- Maintenance center

  One Maintenance Center is established in each TSC area.

- Repair shop

  Repair work is done for electromagnetic parts, telephone sets, maintenance vehicles, and so forth.

- o Training center

  Existing Training Center at Colombo is to be expanded. Basic course training centers, one in each TSC area, are to be newly established.

- o Vehicles

  Vehicles comprise different types to be used for maintenance and operation work.

6.2 Auxiliary Facilities Allocation by Exchange

Each local exchange must have storehouse for consumables. SSC requires storehouse for consumables and simple maintenance parts and tools, plus Lineman Center. Lineman Center consists of storehouse for cables, drop wires, telephone sets, fitting metals, measuring equipment, etc., besides offices for staff linemen.

In some cases, outside plant work is done with cables supplied by SLTD and construction only assigned to contractor. In those cases, storehouse for temporary storage of cables supplied becomes necessary.

Required at TSC are Maintenance Center, Lineman Center, Repair Shop and Training Center. Especially at Maintenance Center, storehouse for bulk storage of maintenance parts and components for use in TSC area, office rooms and electronic computer room are necessary.

Repair Shop requires floor space for storage of faulty parts to be repaired, parts already repaired, and necessary components for repair work.

For training center, Sri Lanka, Telecommunications Training Center exists at Colombo. Besides this, training center to administer basic training for maintenance and operation personnel is to be newly established at each TSC. At this new training center, on-the-job training is the main curriculum.

6.3 Vehicles

At present, mainly in drop wire installation, bicycles are used by reason of mobility. However, tools and implements available are less than necessary so that work efficiency is at extremely low level.

From now forward, some of RSU exchanges will become unattended, i.e., devoid of maintenance and operation staff. Hence the need for utilization of motor vehicles not only in drop wire installation work but in general maintenance and operation also, whereby to quicken work progress and improve work efficiency.

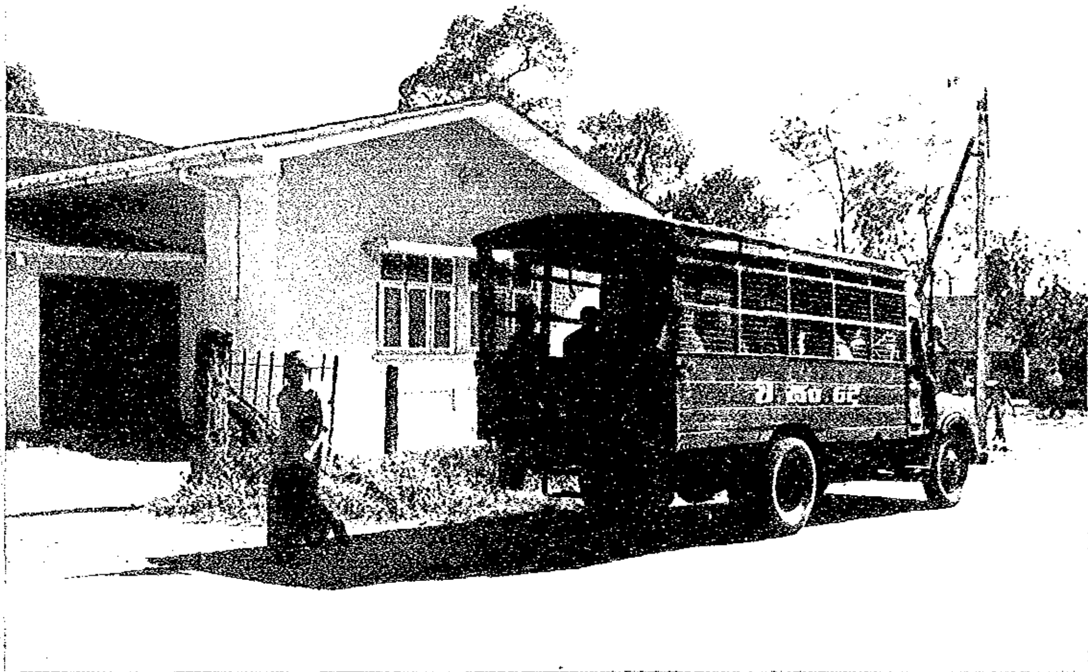
Motor vehicles to be utilized include different types. Among them are cars to carry maintenance squads, trucks to transport maintenance equipment and parts, and special vehicles, such as truck with winch to load and unload heavy goods.

6.4 Auxiliary Facility Project

Auxiliary facilities construction requires no small amount of investment. This investment itself constitutes one of key projects so that, by way of suggestion, investment proposal is made in the latter part of this report.

For implementation of this proposal, in-depth planning parallel with fact-finding about actual situation of each exchange is essential. Furthermore, recommendation is made to enlist cooperation of specialist in this kind of affairs.

CHAPTER 7
NETWORK EXPANSION PLAN



Truck for Maintevance Staff
at Gampaha Exchange

CHAPTER 7 NETWORK EXPANSION PLAN

1. SWITCHING EQUIPMENT EXPANSION PLAN

Switching equipment expansion plan overview is in Figure 7-1. Basic concept underlying this expansion plan is that telephone demand that remained at a level of 107,500 in 1983 will grow by nearly 10 times to the forecasted 1,080,500 in 2000 (refer to CHAPTER 3), and that objective fulfillment rate will attain 100% in that year (refer to CHAPTER 6).

Analog switches will be completely withdrawn and replaced with digital switches in Phase III (1996 - 2000). Digitalization progress in each work phase is in Table 7-1.

Table 7-1 Digitalization Progress by Work Phase

	1983	1985	1990	1995	2000
Digitalization Rate (%)	62	76	90	95	99.9

At the present stage, three types of digital electronic switches, i.e., E-10B, NEAX-61 and NDX-10, are operated. On future occasions of new installations, the same type (or the same system) of switches should be installed in the same area. This is from the viewpoint of spare parts and measuring equipment interchangeability, as well as maintenance/operation method stanardization and personnel training method standardization.

However, for this Master Plan, switches to be installed will not be limited to any specific type (or system). Additional installation plans are in the following tables:

Table 7-2 (1/4): General Expansion Plan by Year
Table 7-2 (2/4): Expansion Plan by Each SSC
Table 7-2 (3/4): Expansion Plan by Each Exchange
Table 7-2 (4/4): Transfer/Replacement Plan

Table 7-3: Expansion Plan for Trunk Exchange

Table 7-4: Transfer Plan of Analog Equipment

Table 7-5: Summary of Cable Expansion Plan of Trunk Switching Equipment

Details of Expansion Plan are shown in Volume II CHAPTER 4.

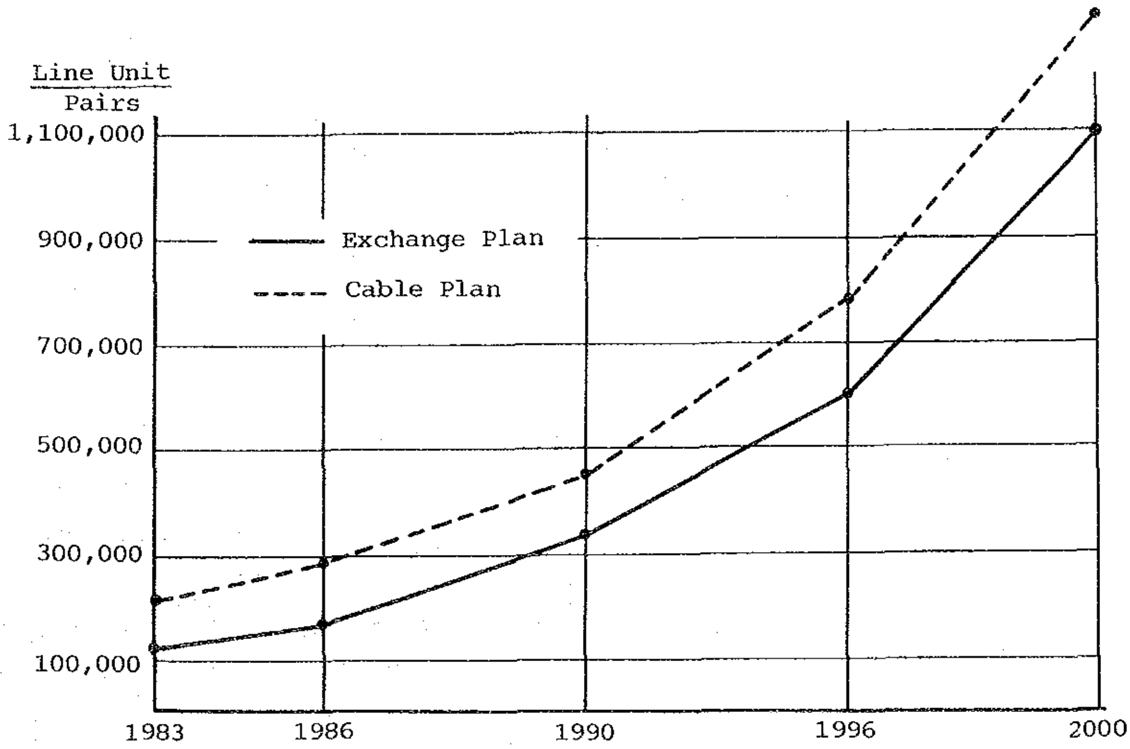


Figure 7-1 Outline of Exchange/Cable Expansion Plan

Table 7-2 General of Expansion Plan (Switching Equipment)

Program \ Phase	Existing	Phase-I (1986-1990)	Phase-II (1991-1995)	Phase-III (1996-2000)
Expansion		213,879	279,393	521,869
Replacement		20,596	1,119	32,015
(Total)	131,466	193,283	278,274	489,854
Gross Total	131,466	324,749	603,023	1,092,877

Table 7-3 (1/4) Summary of Expansion Program by SSC

NO.	CODE	EXISTING	PHASE-I					PHASE-II	PHASE-III
			1986	1987	1988	1989	1990	1995	2000
1	ANR	2008			1544			2812	5176
2	AMR	500				600			2700 (-1100)
3	AVS	1664				1528		960	3312
4	BDL	2177				1432 (-25)		2700	4960
5	BTC	1200			3700 (-1000)			2300	5836 (-1200)
6	BNR	1472				988		2020	3788
7	CNT	76700	54250 (-12500)	23800	27350	9900	16300	178800	323200 (-12000)
8	CHW	1170		2672 (-1170)				240	2320
9	GLE	2696				6124	192	6364	12244 (-1880)

Table 7-3 (2/4) Summary of Expansion Program by SSC

NO.	CODE	EXISTING	PHASE-I					PHASE-II	PHASE-III
			1986	1987	1988	1989	1990	1995	2000
10	GMH	1150	4038 (-1150)					3056	5864
11	HMB	4044						750	2586
12	HTN	900	2308 (-900)					1724	3540
13	JFN	5426				8590		13360	23980
14	KLM	900				1500 (-600)		2050	3800 (-300)
15	KND	6825		552 (-225)	7000	1824 (-800)	3433	16720	37516 (-6160)
16	KRG	2838					2864	4900	8436
17	KLT	1592				3888 (-288)		3960	7496
18	KGL	1664				192		2544	3140

Table 7-3 (3/4) Summary of Expansion Program by SSC

NO.	CODE	EXISTING	PHASE-I					PHASE-II	PHASE-III
			1986	1987	1988	1989	1990	1995	2000
19	MNR	1140				800 (-50)		2816 (-1090)	479 (-500)
20	MTL	1516					1876	2668	5080 (-300)
21	MTR	1712	4400 (-832)					3645	7420 (-880)
22	NWL	460		1376 (-460)				700	1200
23	NGM	3429				6520		10276	18544 (-2805)
24	NWR	1796					1528 (-100)	3288	4640
25	PLN	650						988	1972 (-650)
26	PND	900		3720 (-20)				2624	6900 (-880)
27	PTL	390					2230 (-390)		996

Table 7-3 (4/4) Summary of Expansion Program by SSC

NO.	CODE	EXISTING	PHASE-I					PHASE-II	PHASE-III
			1986	1987	1988	1989	1990	1995	2000
28	RTN	1672			2460			3776	6724
29	TRN	1778			144 (-18)		700	2020	3684 (-800)
30	VNY	1097		1550 (-68)				1332 (-29)	4336 (-2550)
	Total	131466	65000 (-15382)	33670 (-1943)	42198 (-1018)	43886 (-1763)	29125 (-490)	279393 (-1119)	521869 (-32015)

Table 7-4 Transfer Plan of Analog Equipment

Type of Equip	From				To	
	SSC	Name of Exchange	Year	L.U.	SSC	Name of Exchange
XB	MTR	Weligama	1986	150	GMH	Pallewela
	NWL	Nawalapitiya	1987	360	KND	Rikillagoskada
	GMH	Gampaha	1986	800	VNY	Mulativu
	HTN	Hatton	1986	550	VNY	Nedunkerni
XB/SE	KND	Gampola	1989	500	MNR	Talaimannar
	BTC	Batticaloa	1988	1000	BTC	Valachchanai
	CHW	Chilaw	1987	1000	CHW	Marawila
	KLM	Kalmunai	1989	600	AMR	Ampara
ERS	KND	Madulkele	1987	200	VNY	Padaviya
HDX	PTL	Puttalam	1990	300	PTL	Anamaduwa
RSU	KLT	Bentota	1989	288	KLT	Matugama

Table 7-5 Summary of Expansion Plan of Trunk Switching Equipment

Trunk Switching Equipment (Unit)	Existing	Phase-I	Phase-II	Phase-III
XB	6	6	6	-
XB/SE, HDX	20	20	20	-
ESS	16	26	32	32
SXS	1	-	-	-
(Total)	43	52	58	32

Kind of Exchange Hierarchy

TS: Trunk Switching

TLS: Trunk and Local Switching combined

2. CABLE NETWORK EXPANSION PLAN

Cable network expansion schedule is in Figure 7-1. Expansion begins with existing 277,400 pairs and finally reaches 1,465,000 pairs in the year 2000.

In this report, expansion works already scheduled by SLTD are handled as existing facilities.

Existing 277,400 pairs will be expanded to 456,900 pairs in 1990. That is to say, expansion by 178,300 pairs will be carried out during 1986 through 1990. This figure does not include scheduled expansion by Greater Colombo telecommunications network improvement plan.

As for efficiency of existing subscriber cable facilities, how long can the existing number of primary cable pairs cover the telephone demand has been examined. Study result is shown in Figure 7-2, detailed calculation appear in Volume II Table 4-9.

2.1 Subscriber's Cable Expansion Plan

On the basis of the covering duration of the existing primary cable facilities the subscriber's cable expansion plan is made as shown in Table 7-6 and Figure 7-3.

Subscriber's cable expansion plan consists of subscriber's cable expansion by 1,192,600 pairs, as well as additional conduit and manhole construction.

2.2 Junction Cable Expansion Plan

On the basis of the estimated number of TELEX and leased circuits as well as telephone circuits, the junction cable expansion plan has been prepared.

For junction cable system, selection is made for PCM system. Motivation is to keep abreast of switching equipment digitalization and ISDN orientedness.

The number of proposed cable systems by the year 1990 is 45 sections with 530 pairs and 798 km length.

The number of proposed PCM transmission system for the year 1990 is 113.

Existing System	Phase-I	Phase-II	Phase-III
Number of PCM System 145 (277)	113 (394)	99 (683)	154 (1,260)

( ) is Colombo Area.

2.3 Work Schedule

For outside plant construction, financial plan and technical study assume major important in working plan.

Study of working plan must commence 24 to 26 months before scheduled service-in period. Main items of study are of technical nature. Chief among them are choice between conduit cable system and aerial cable system, primary and secondary cable laying and termination method, decision of cable conductor diameter and of cable size, and cable route selection.

Outside plant construction cost is estimated at US$500 per pair at present. Timing arrangement for financing requires careful study.

Also to be considered in working plan are necessary arrangements for site land acquisition, exchange building construction, and equipment/materials procurement. Most important of all is to so arrange that fully coordinated working plan will be carried out according to schedule.

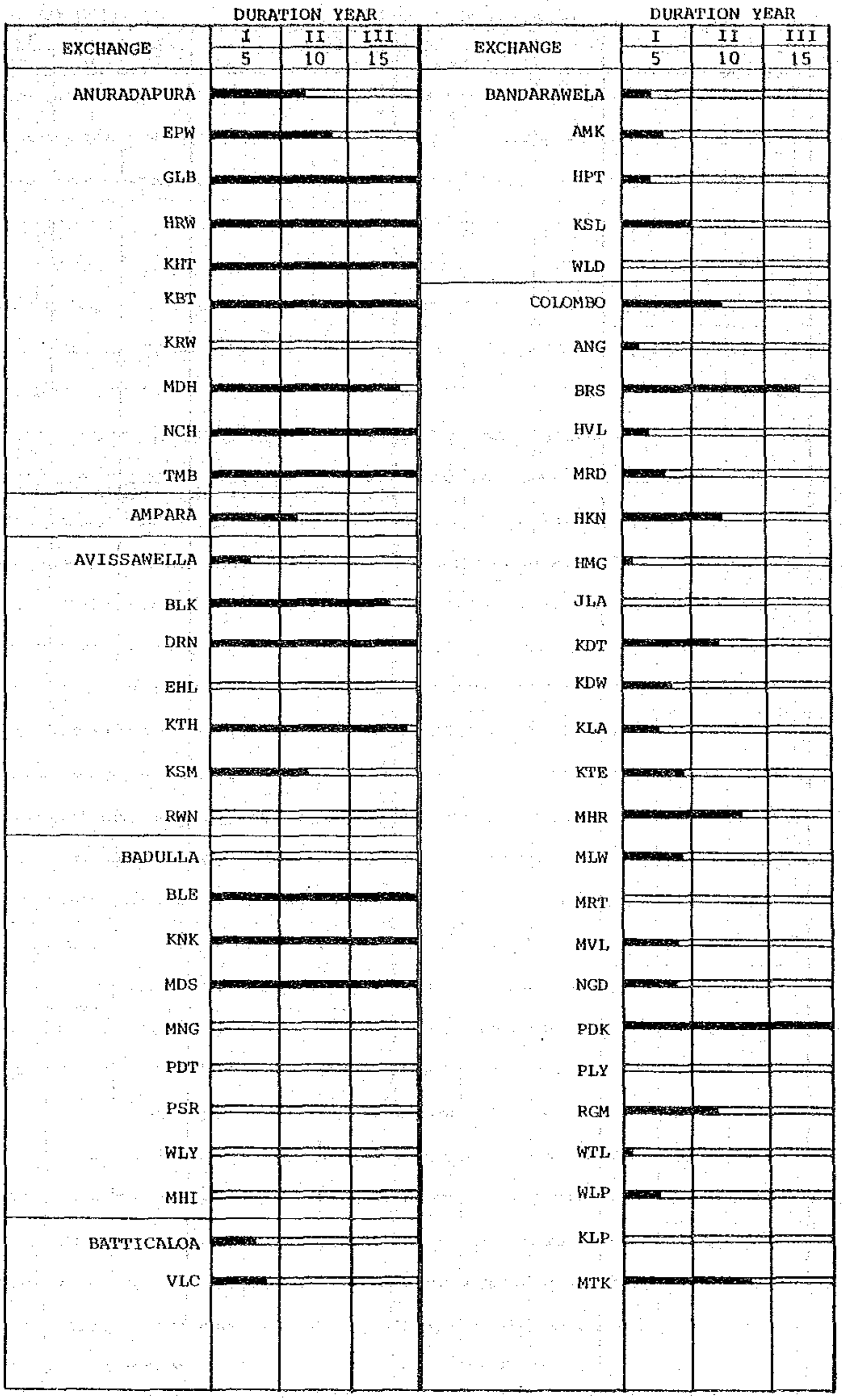


Figure 7-2 (1/4) Summary of Duration Year (Primary Cable)

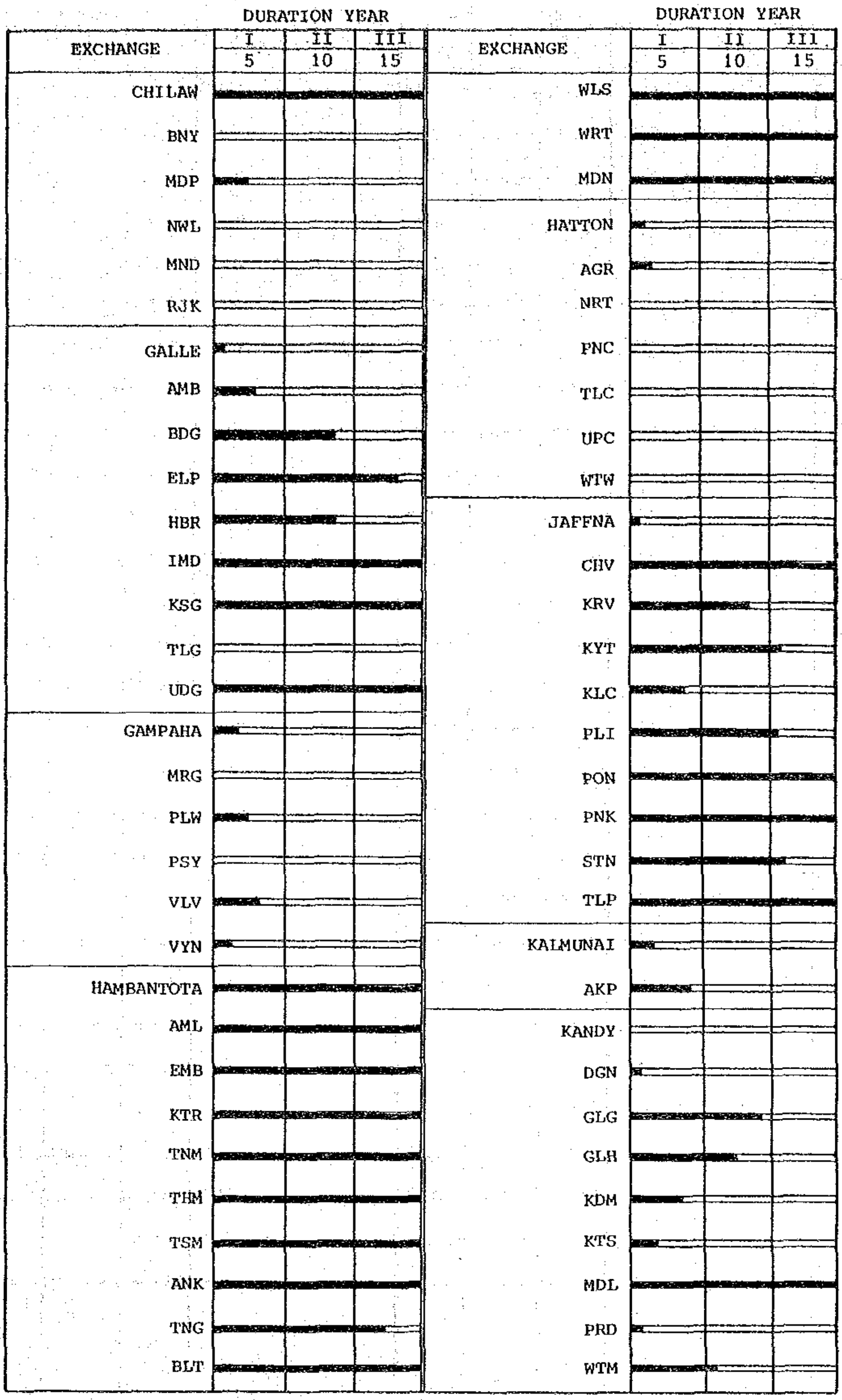


Figure 7-2 (2/4) Summary of Duration Year (Primary Cable)

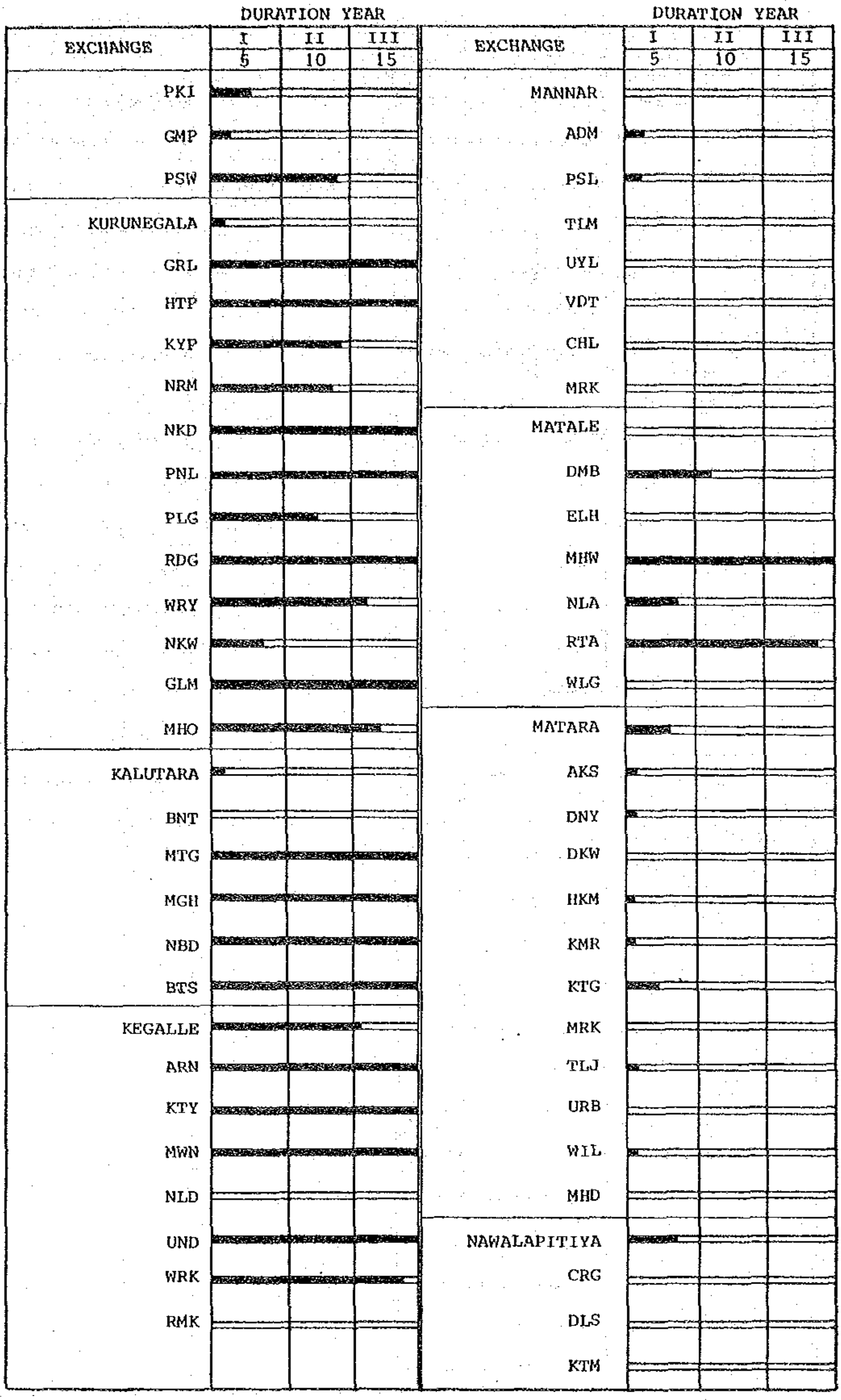


Figure 7-2 (3/4) Summary of Duration Year (Primary Cable)

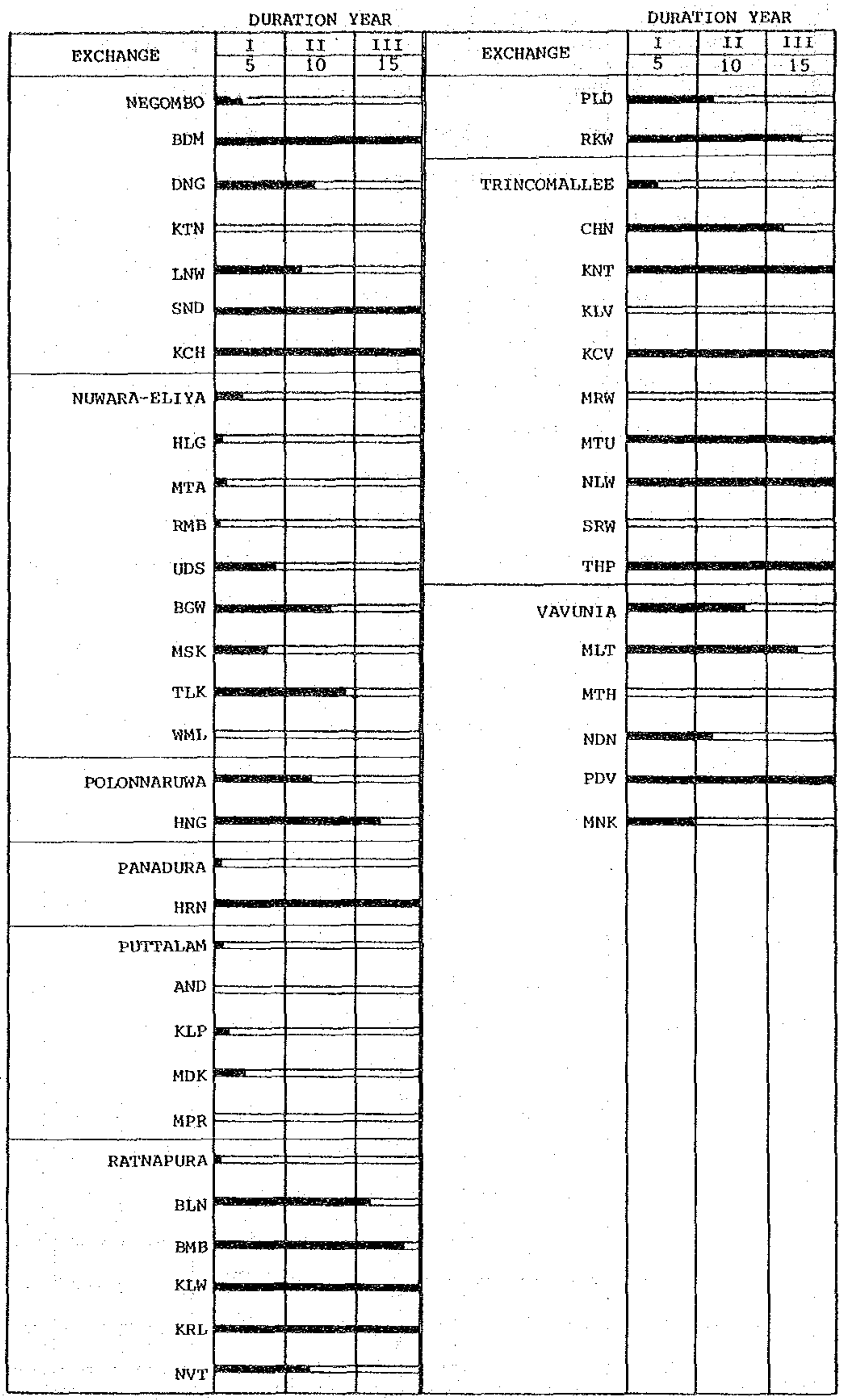


Figure 7-2 (4/4) Summary of Duration Year (Primary Cable)

Table 7-6 (1/2) Summary of Cable Expansion Plan

S.S.C.	PLANNED BY SLTD	EXISTING	PHASE-I					II	III	TOTAL
			1986	1987	1988	1989	1990	1995	2000	
ANURADAPURA	5,600	900						2,400	6,300	15,200
AMPARA		900						1,100	1,600	3,600
AVISSAWELLA	1,100	604	400			1,500		1,200	4,500	9,304
BADULLA	900	175	600			1,700		3,300	5,300	11,975
BATTICALOA		2,800			2,400			2,900	5,900	14,000
BANDARAWELA		1,350	500			1,200		2,500	5,200	10,750
COLOMBO	89,100	87,775	13,900	19,400	26,800	7,600	17,500	250,400	398,500	910,975
CHILAW	1,400	525		1,500				700	1,900	6,025
GALLE	2,500	3,050				7,600		8,300	18,300	39,750
GAMPAHA		1,835	3,700					3,900	7,500	16,935
HAMBANTOTA	5,640	1,520						100	3,300	10,560
HATTON		979	2,300					2,300	4,500	10,079
JAFFNA	8,050	3,300	9,700			400		15,000	30,400	66,850
KALMUNAI		1,550				2,400		1,000	5,300	10,250
KANDY		9,050	200	200	16,900	1,000	400	18,500	56,800	103,050
KURUNEGALA	5,100	1,700					2,700	5,000	10,800	25,300

Table 7-6 (2/2) Summary of Cable Expansin Plan

S.S.C.	PLANNED BY SLTD	EXISTING	PHASE-I					II	III	TOTAL
			1986	1987	1988	1989	1990	1995	2000	
KULUTARA	2,700	1,900				3,900		4,200	9,100	21,800
KEGALLE	4,300	1,010						800	3,600	9,710
MANNAR		289	1,100			1,100	2,800		1,500	6,789
MATALE	1,200	1,300	100				2,100	3,500	6,100	14,300
MATARA		2,390	4,100					5,100	8,100	20,230
NAWALAPITIYA		712		1,300				900	1,600	4,512
NEGAMBO	4,500	1,600				8,400		12,000	20,000	46,500
NUWARA-ELIYA	500	2,152	700				100	2,900	8,000	14,352
POLONNARUWA		1,400						800	1,700	3,900
PANADURA	1,600	1,600		2,800				3,500	7,800	17,300
PUTTALAM		260	200				2,700		1,500	4,660
RATNAPURA	2,900	1,275			2,200			4,100	8,600	19,075
TRINCOMALEE	2,100	1,200					800	1,900	3,700	9,700
VAVUNIYA	2,200	375		1,400				1,400	2,300	7,675
TOTAL	141,390	136,016	37,500	26,600	48,300	36,800	29,100	395,500	649,700	1,464,906

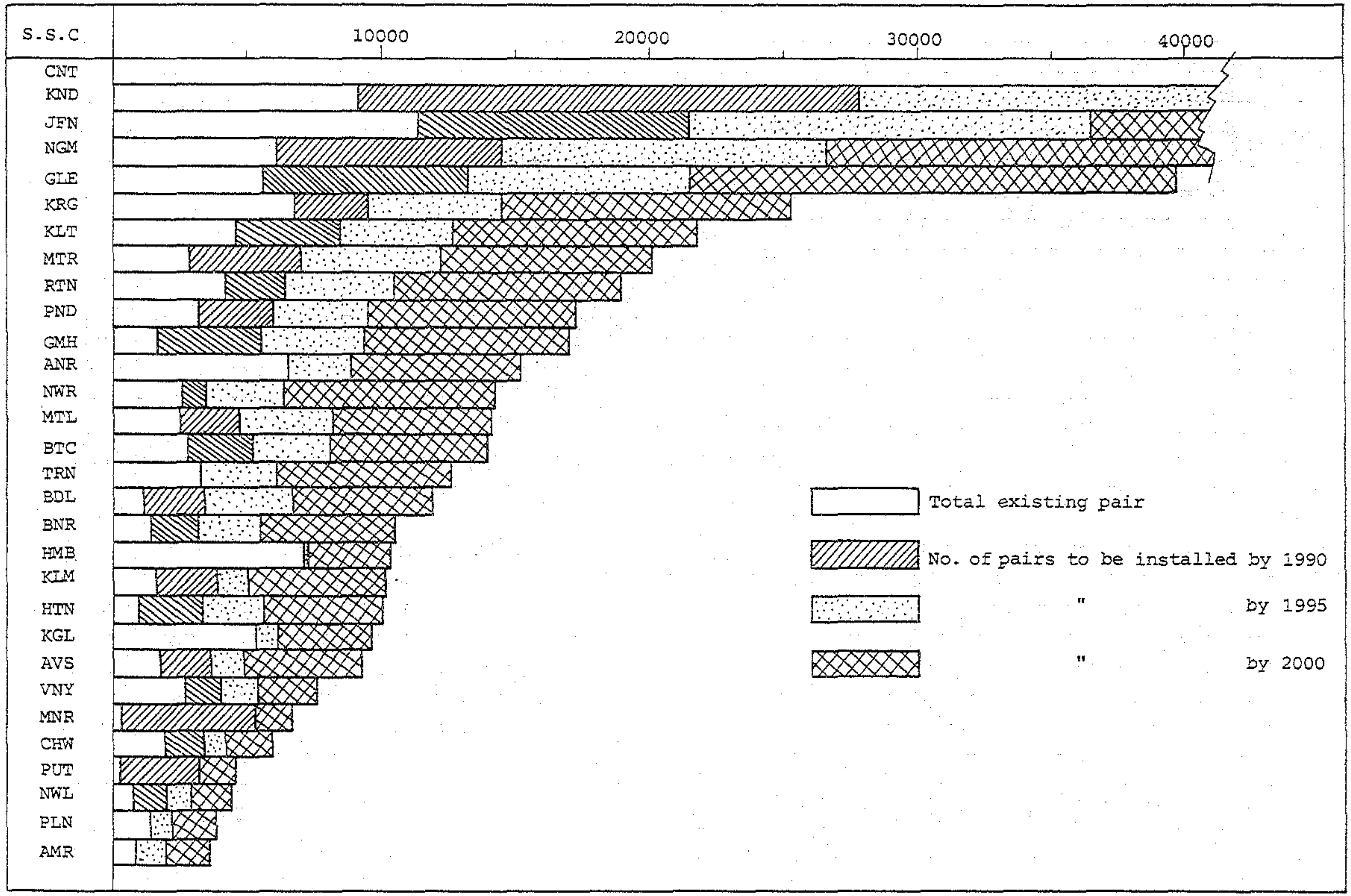


Figure 7-3 Expansion Program for Primary Cable

Table 7-7 (1/4) Summary of Junction System Expansion Plan

TSC		SSC AREA	2Mb/s systems Required				Existing		Expansion			Phase I					II	III
CODE	NO.		1985	1990	1995	2000	Type of system	No. of 2M sys	Proposed system	No.of Sect.	Dist (km)	1986	1987	1988	1989	1990	By 1995	By 2000
ANR	1	Anuradapura Area	9	10	11	15	Radio 2GHz 17Mb	8	Radio 2GHz 17Mb	2	—						1	1
							Radio 2GHz 4Mb	4										
							C.PCM 0.63/20	3										
	2	Mannar Area	7	7	7	8	Open wire	—	C.PCM 0.9/10	2	45					2+2		
									C.PCM 0.63/10	4	46					4+4		1
									C.PCM 0.63/20	1	15					1+1		
	3	Jaffna Area	10	17	28	48	Radio 8GHz 68Mb	3	Radio 8GHz 68Mb	1	—						1	4
							Radio 2GHz 17Mb	8	Radio 2GHz 17Mb	2	—						3	8
							Radio 2GHz 4Mb	3	Radio 2GHz 4Mb	1	—							1
							C.PCM 0.63/20	13	PCM	3	(32)						3+3	9
			4*	7*	12*	21*			Muiti Access	2	—				7*		5*	9*
	4	Vavuniya Area	7	7	9	13	Open wire	—	Radio 2GHz 17Mb	2	—		2				1	1
							Radio Single CH	—	Radio 2GHz 4Mb	1	—						1	1
							Radio 800M 120CH	—	C.PCM 0.9/10	2	84		2+2				1	
									C.PCM 0.63/40	1	12		2+1				2	2
	5	Trincomalee Area	17	17	19	20	Radio 8GHz 68Mb	1										
							Radio 2GHz 17Mb	4										
							Radio 2GHz 4Mb	4										
							C.PCM 0.63/60	9										
							C.PCM 0.63/20	3										
							C.PCM 0.63/10	2										
	6	Polonnaruwa Area	1	1	2	4	Radio 250M 24CH	—	C.PCM 0.63/10	1	11						2+1	2

NOTE : Figures with * mark show the number of radio channels of MAS system.

Table 7-7 (2/4) Summary of Junction System Expansion Plan

TSC		SSC AREA	2Mb/s systems Required				Existing		Expansion			Phase I					II	III
CODE	NO.		1985	1990	1995	2000	Type of system	No. of 2M sys	Proposed system	No.of Sect.	Dist (km)	1986	1987	1988	1989	1990	By 1995	By 2000
KND	1	Kandy Area	17	27	42	69	Radio	—	C.PCM 0.63/10	1	26						2+1	2
							Metalic cable	—	PCM	10	(166		1+1	10+2	7+2	3+1	17+3	26+1
	2	Matale Area	6	7	8	13	Radio 2GHz 4Mb	2										
							C.PCM 0.63/10	2	PCM	2	(40)						1+1	3+1
							C.PCM 1.27/8	1	PCM	1	(21)							1+1
	3	Batticaloa Area	1	2	3	4	Open wire	—	C.PCM 0.9/20	1	30			2+1			1	2
	4	Kalmunai Area	2	4	6	7	Radio 400M 60CH	—	C.PCM 0.63/20	1	26				4+1		2	1
	5	Ampara Area																
	6	Badulla Area	9	10	14	19	Radio 4GHz 68Mb	1										
							Radio 2GHz 34Mb	4	Radio 2GHz 34Mb	1	—						2	1
							Radio 2GHz 17Mb	6										
							Radio 2GHz 4Mb	3	Radio 2GHz 4Mb	1	—							1
							C.PCM 0.63/20	6	PCM	1	(20)							2+1
							C.PCM 0.63/10	4										
	7	Bandarawela Area	6	7	9	13	Radio 2GHz 17Mb	1										
							Radio 2GHz 4Mb	1										
							C.PCM 0.63/30	2										
							C.PCM 0.63/20	6	PCM	2	(35)							3+2
							C.PCM 0.63/10	1										
	8	Nuwara-Eliya Area	8	8	12	16	Radio 2GHz 4Mb	4	Radio 2GHz 4Mb	3	—						2	3
							C.PCM 0.9/20	2	PCM	2	(17)						2+2	1
							C.PCM 0.63/30	2										
							C.PCM 0.63/10	4										

Table 7-7 (3/4) Summary of Junction System Expansion Plan

TSC		SSC AREA	2Mb/s systems Required				Existing		Expansion			Phase I					II	III
CODE	NO.		1985	1990	1995	2000	Type of system	No. of 2M sys	Proposed system	No.of Sect.	Dist (km)	1986	1987	1988	1989	1990	By 1995	By 2000
KND	9	Hatton Area	6	6	7	11	Open wire	—	C.PCM 0.63/10	6	122	6+6					1	4
	10	Nawalapitiya Area	3	3	3	3	Open wire	—	C.PCM 0.63/10	3	31		3+3					
CNT	1	Chilaw Area	12	15	20	28	Open wire	—	Radio 2GHz 34Mb	1	—		1					
							Mono-coaxial	—	Radio 2GHz 17Mb	1	—					5	3	5
									Radio 2GHz 4Mb	1						1		
									C.PCM 0.9/10	1	30					1+1		
									C.PCM 0.63/10	6	89		5+4			2+2	2	3
	2	Kurunegala Area	22	24	36	61	Radio 2GHz 17Mb	15	Radio 2GHz 17Mb	5	—						1	8
							Radio 2GHz 4Mb	2	Radio 2GHz 4Mb	1	—							1
							C.PCM 0.63/80	21	PCM	1	(3)						6+1	11
							C.PCM 0.63/50	4	PCM	1	(21)							2+1
							C.PCM 0.63/20	1	PCM	1	(19)							1+1
							C.PCM 0.63/10	2	PCM	1	(18)							1+1
	3	Kegalle Area	7	7	10	15	C.PCM 0.63/30	3	PCM	1	(13)							2+1
							C.PCM 0.63/20	2	PCM	1	(20)							2+1
							C.PCM 0.63/10	5	C.PCM 0.63/10	1	10						1+1	
	4	Gampaha Area	5	6	10	18	Radio 2GHz 4Mb	4	Radio 2GHz 4Mb	2	—	1						2
							Cable 0.63/30	—	PCM	1	(11)	2+1					2	3
							Open wire	—	C.PCM 0.63/10	2	14	2+2					1	2
	5	Avissawella Area	6	9	11	18	C.PCM 0.63/20	8	PCM	3	(46)							7+3
							C.PCM 0.63/10	4										

Table 7-7 (4/4) Summary of Junction System Expansion Plan

TSC		SSC AREA	2Mb/s systems Required				Existing		Expansion			Phase I					II	III
CODE	NO.		1985	1990	1995	2000	Type of system	No. of 2M sys	Proposed system	No.of Sect.	Dist (km)	1986	1987	1988	1989	1990	By 1995	By 2000
CNT	6	Kalutara Area	6	9	11	18	C.PCM 0.9/32	1	PCM	1	(21)				3+1		2	3
							C.PCM 0.63/30	3	PCM	1	(24)						1+1	3
							C.PCM 0.63/10	3	PCM	1	(21)							1+1
	7	Panadura Area	2	3	5	9	Open wire	—	C.PCM 0.63/20	1	20		3+1				2	4
	8	Negombo Area	5	7	12	17	C.PCM 0.63/20	6	PCM	3	(45)						3+2	5+1
							C.PCM 0.63/10	2	PCM	1	(25)						1+1	
	9	Colombo Area							C.PCM 1172 pairs	12	66.3	346					669	1203
									Fiber 140Mb/12C	1	11.4	48					14	57
GLE	1	Galle Area	9	11	16	26	Radio 4GHz 68Mb	2	Radio 4GHz 68Mb	2	—				4		3	6
							Radio 2GHz 4Mb	1	Radio 2GHz 4Mb	1	—							1
							Metalic cable	—	C.PCM 0.63/30	1	5				4+1		3	5
							C.PCM 0.63/20	2	PCM	1	(17)							1+1
							C.PCM 0.63/10	6	PCM	2	(49)						1+1	2+1
	2	Ratnapura Area	8	10	15	25	Radio 4GHz 68Mb	2	Radio 4GHz 68Mb	1	—							1
							Radio 2GHz 17Mb	2	Radio 2GHz 17Mb	1	—						1	4
							C.PCM 0.63/20	7	PCM	4	(59)			1+1			4+2	10+1
							C.PCM 0.63/10	3										
	3	Hambantota Area	18	23	29	34	Radio 2GHz	16	Radio 2GHz	10	—						10	4
							C.PCM	7	PCM	5	(25)						5+5	2
	4	Matara Area	10	12	16	22	Open wire	—	Radio 4GHz 68Mb	1	—	2						1
							Metalic cable	—	C.PCM 0.63/20	4	82	6+4					2	6
									C.PCM 0.63/10	6	102	6+6					2	

3. TRANSMISSION AND RADIO SYSTEM EXPANSION PLAN

As-built concept of trunk transmission network in the year 2000 appears in Figure 7-4. Analog type transmission and radio equipment will be completely withdrawn in Phase II (1991 - 1995). This means that transmission route digitalization will be realized 100% by 1995. Transmission route digitalization progress by work phase is in Table 7-8. Trunking route does not include Greater Colombo area.

Table 7-8 Transmission Route Digitalization Progress

	1983	1985	1990	1995	2000
Trunk Route	0%	66.2%	98.4%	100%	100%
Junction Route	0%	86.6%	99.2%	100%	100%

In order to economize necessary investment, transmission route digitalization is to be carried out on the same occasion as switching equipment digitalization. Analog-digital converter (CODEC) is not used unless absolutely necessary.

In existing digital trunk transmission routes, digital microwave system is adopted in most cases. Almost all sections can satisfy circuit requirement up to the year 2000 with existing system capacity. In those sections, system expansion should be by existing system expansion to the limits of existing system capacity.

Exceptions are two sections, i.e., Colombo Central - Kandalama Repeater Station and Berungala Repeater Station - Primrose - Hill Repeater Station. In these two sections, circuit requirement exceeding existing system capacity is foreseen so that, for a remedy, 4 GHz band and 8 GHz band systems will be newly introduced.

Especially, on existing route between Colombo Central and Kandalama Repeater Station, circuits in the directions of Anuradapura Exchange and Kandy Exchange are concentrated so that extremely large route capacity is required. Thus, alternative route by way of Colombo Central, Negombo Exchange and Kandalama Repeater Station is introduced to improve route performance reliability. At Berungala Repeater Station, branch route in the direction of Kirimetiyakanda Repeater Station for transmission route toward Batticaloa Exchange will be newly established.

For both those branch routes, branching angle is narrow at 35° or thereabouts so that front-to-side and front-to-back radio interferences are intense. However, in both cases, the number of systems required is small, i.e., 2+1. Therefore, by means of different polarizations on main route and branch routes, radio interferences can be prevented.

140 M bit/s optical fiber system is introduced between Kandy Exchange and Primrose-Hill Repeater Station from demand forecasting. Since the distance of this repeater section is short, i.e., less than 5 km, optical fiber to be used can be of low quality standard of 500 MHz.km. Hence lower cost, compared with 34 M bit/s system.

For new route establishment, system selection should be from among systems already adopted. Transmission routes to be newly established wherein route selection assumes major importance are those to Polonnaruwa, Baticaloa, Kalmunai and Ampara Secondary Switching Centers (SSC).

Figure 7-4 introduces selected routes in consideration of repeater spacing and number of repeater stations required between Tertiary Switching Center (TSC) and each of those SSCs and from the viewpoint of best possible utilization of existing facilities. For transmission system, primary choice is for radio system. In this case, repeater stations to be newly established number four and existing repeater stations that can be utilized number two.

Radio system connections between TSC and SSC are seven at maximum whereas maximum route length is 250 km or thereabouts. Hence no serious implication in transmission performance.

On the selected routes for new transmission routes, analog UHF system and coaxial cable system are already introduced so that new system and existing systems are basically to coexist. Between Chillaw Exchange and Wariyapola Repeater Station, transmission route is to be newly established for the purpose of route diversifying.

Optical fiber system is introduced between Katunayaka Exchange and Negombo Exchange since the distance of this section is short, i.e., less than 10 km. For 140 M bit/s optical fiber cable system, quality standard required of fiber cable can be 800 MHz.km. That is, cost is low enough, compared with 34 M bit/s system. Table 7-9 presents summary of trunk route expansion plan. In CHAPTER 3 of Volume II circuit grouping diagram is shown. In CHAPTER 4 of Volume II expansion plan for each section and for each area is also presented.

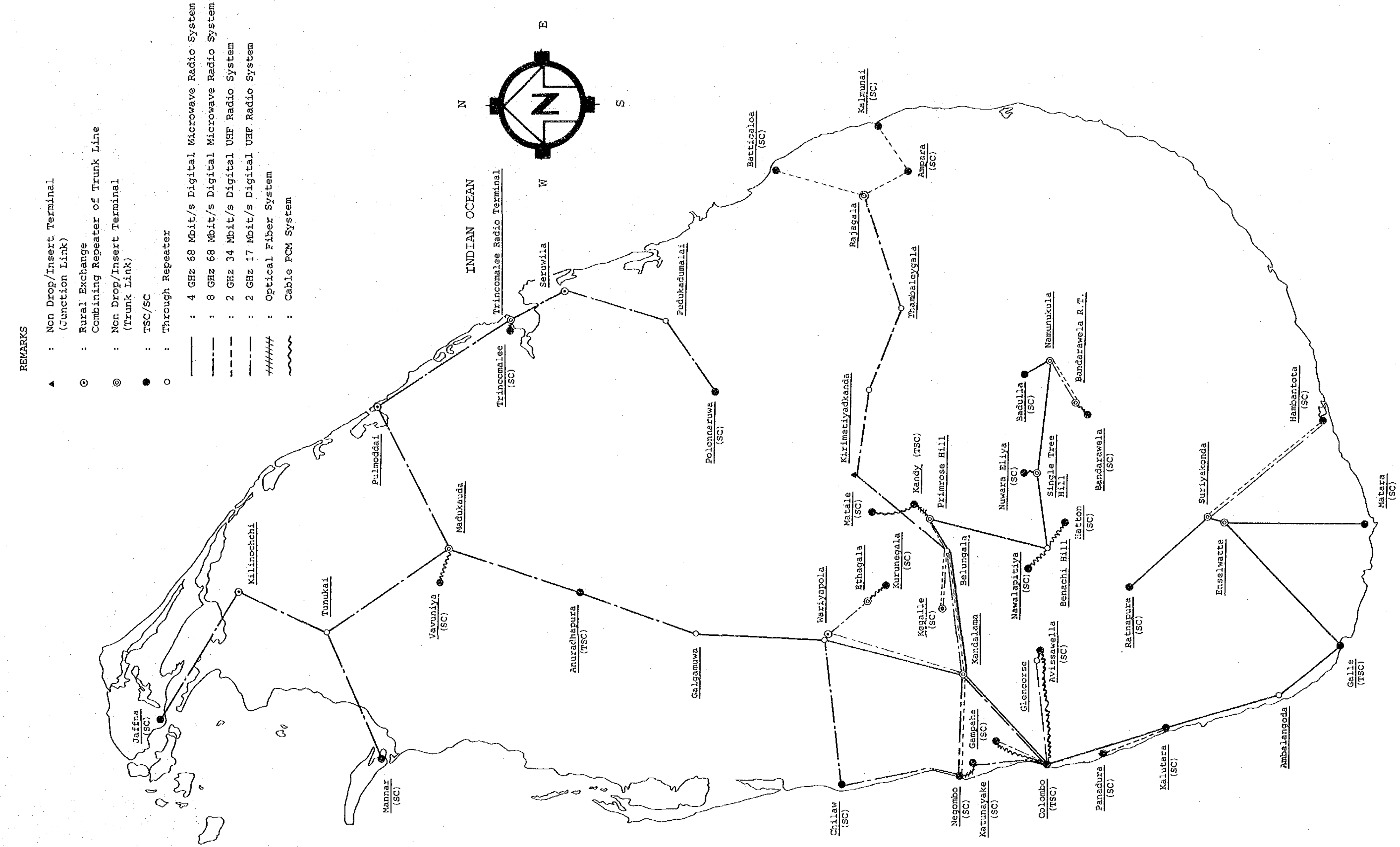


Figure 7-4 Transmission Network Configuration in the Year 2000 (Trunk Route)

Table 7-9 Summary of Transmission System Expansion Plan (Trunk Route)

TSC		AREA NAME	2Mb/s systems Required				Existing		Phase I					Phase II	Phase III
CODE	NO.		1985	1990	1995	2000	Type	No. of 2M sys	1986	1987	1988	1989	1990	By 1995	By 2000
	1	TSC - TSC	40	74	131	225	Digital	49			15	13		54	94
ANR	2	Anuradapura Area	35	63	110	201	Digital	9		9		19	17	56	91
KND	3	Kandy Area	46	83	136	216	Digital	16	9	8	9	25	9	60	80
CNT	4	Colombo Area	37	71	119	193	Digital	29	1	13		20	6	48	79
GLE	5	Galle Area	22	38	66	117	Digital	12	18		7			29	51
		TOTAL	180	329	562	952		112	28	30	31	77	32	247	395

CHAPTER 8
ECONOMIC/FINANCIAL ANALYSIS

Rural Area

CHAPTER 8 ECONOMIC/FINANCIAL ANALYSIS

1. INTRODUCTION

1.1 Objective

For the formulation of Sri Lanka national telecommunications network improvement plan, two points must be clarified. One is the scale of investment. The other is the order of priority for investment. In concrete terms:

(1) As of 1983, a total of 73,425 telephones are installed and used. Nevertheless, an estimated 34,120 applicant subscribers still remain on the waiting list. What, then, is the appropriate scale of investment for telephone service expansion?

(2) In the whole country, 231 telephone exchanges exist. Among these telephone exchanges, the subscriber backlog rate is widely apart from 12% to 49%. Hence considerable difference in the degree of urgency to cater for subscriber demand. Which telephone exchange should be the first to have service expansion underway?

Furthermore, by the financial analysis, two other points must be clarified. They are:

(3) Whichever, the Government or the private business entity, undertakes project implementation, can it break even or not? The answer depends upon cost accounting.

(4) In what manner should the ideal plan and actual restraints (i.e., financial/technical

availabilities) be combined best? This, after all, reflects implementation planning feasibility.

1.2 Methodology

For determining investment scale and investment priority in telecommunications project implementation, two indicators must be carefully studied. They are Internal Economic Rate of Return (IERR) and Internal Financial Rate of Return (IFRR).

(1) IERR provides methodology whereby to plan the fittest pattern of telecommunications project from the viewpoint of most desirable and most effective utilization of national resources, by means of comparison between expenditure entailed upon and benefits accruing to the national treasury.

(2) IFRR provides methodology whereby to so adjust telecommunications project cost and revenue that maximum profit will result.

1.3 Correlation

The corollary is that the higher the IRR, the higher the order of priority.

In this report, calculation is made for both IERR and IFRR. Calculation result for IERR is described in economic analysis and that for IFRR in financial analysis.

IERR takes precedence over IFRR. This means that as long as the telecommunications project implementing entity, be it SLTD as government organization or competent public corporation or private commercial company, exists in Sri Lanka, its primary concern is to make optimum use of national resources, and, for this purpose, the scale of investment and the order of priority for investment must first be determined by IERR, and, after this, the financial balance between project revenue and expenditure must be carefully examined by IFRR.

Reasons why IERR takes precedence over IFRR are four-fold. They are:

(1) Telecommunications service as public property must be provided at high quality, at low price and with equality to all parties.

(2) Telecommunications service must contribute to national profits.

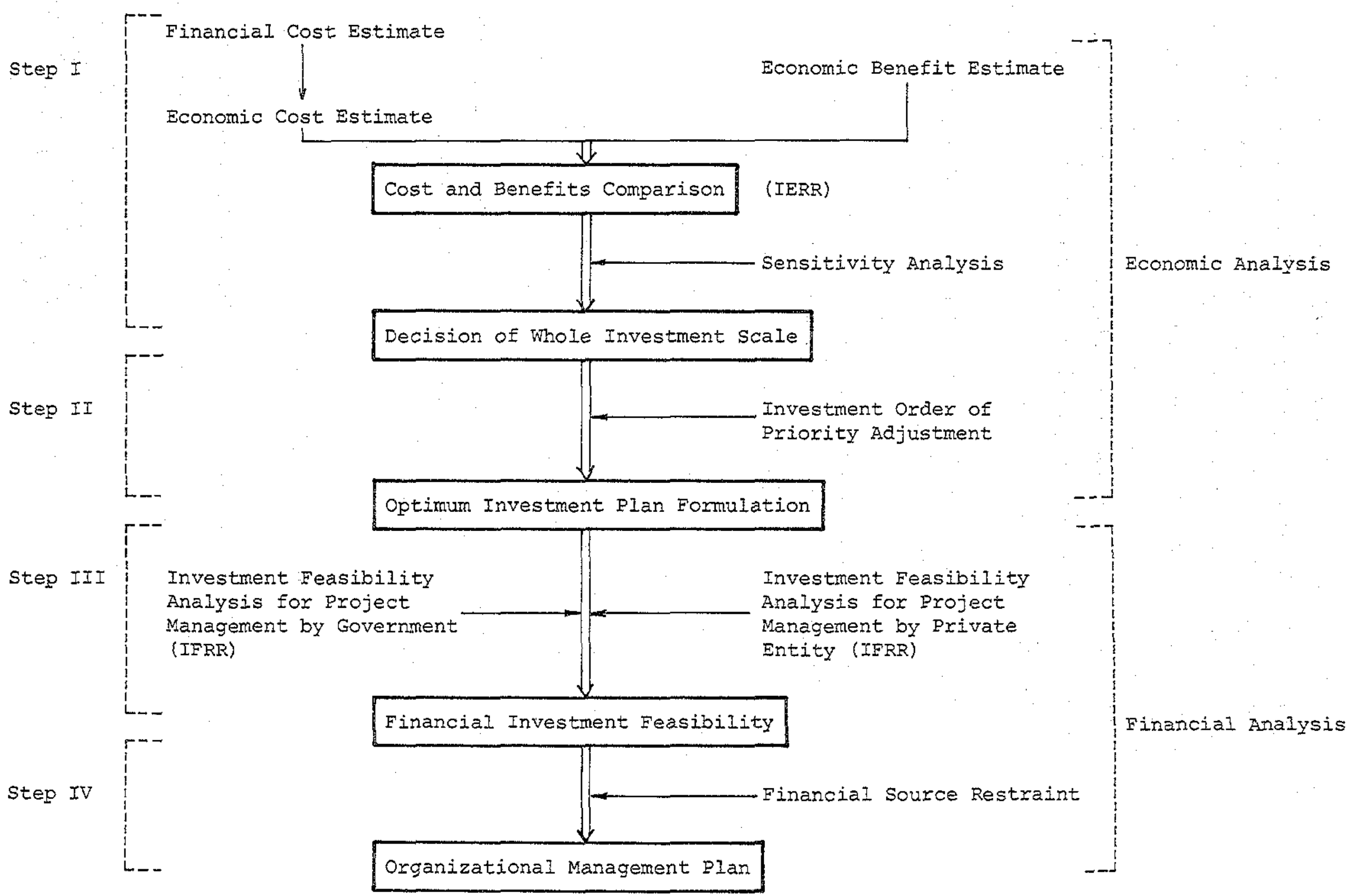
(3) Commercial management propensity to alienate service as public property must be restrained.

(4) National resources must be utilized to the utmost so as to ensure satisfactory performance of telecommunications.

1.4 Planning Methodology/Procedure

Planning methodology and procedure are as under.

Planning Methodology and Procedure



1.5 Project Coverage

Existing facilities including 73,425 telephones (as of 1983) available to users, or, more precisely, switchboards at 231 Local Exchanges (LE), switchboards at 30 Secondary Service Centers (SSC), user-LE cables, LE-SSC cables and facilities to be newly established by on-going projects are not considered for the scale of investment and the order of priority for investment taken up for study in this chapter.

Objectives of planning and evaluation, this time, consist of additional telephone demand to be newly catered for and resultant investment increment.

To take up for evaluation all facilities including existing facilities plus facilities to be newly established by on-going projects may be one method. This time, however, such method is not adopted by reason of lack of data available concerning existing facilities.

1.6 Project Units

In Sri Lanka, a total of 231 LEs exist. Investment planning for all those LEs is impracticable. The alternative is to classify those LEs into several groups so that each group can serve as project unit. Project unit location map is in Figure 8-1.

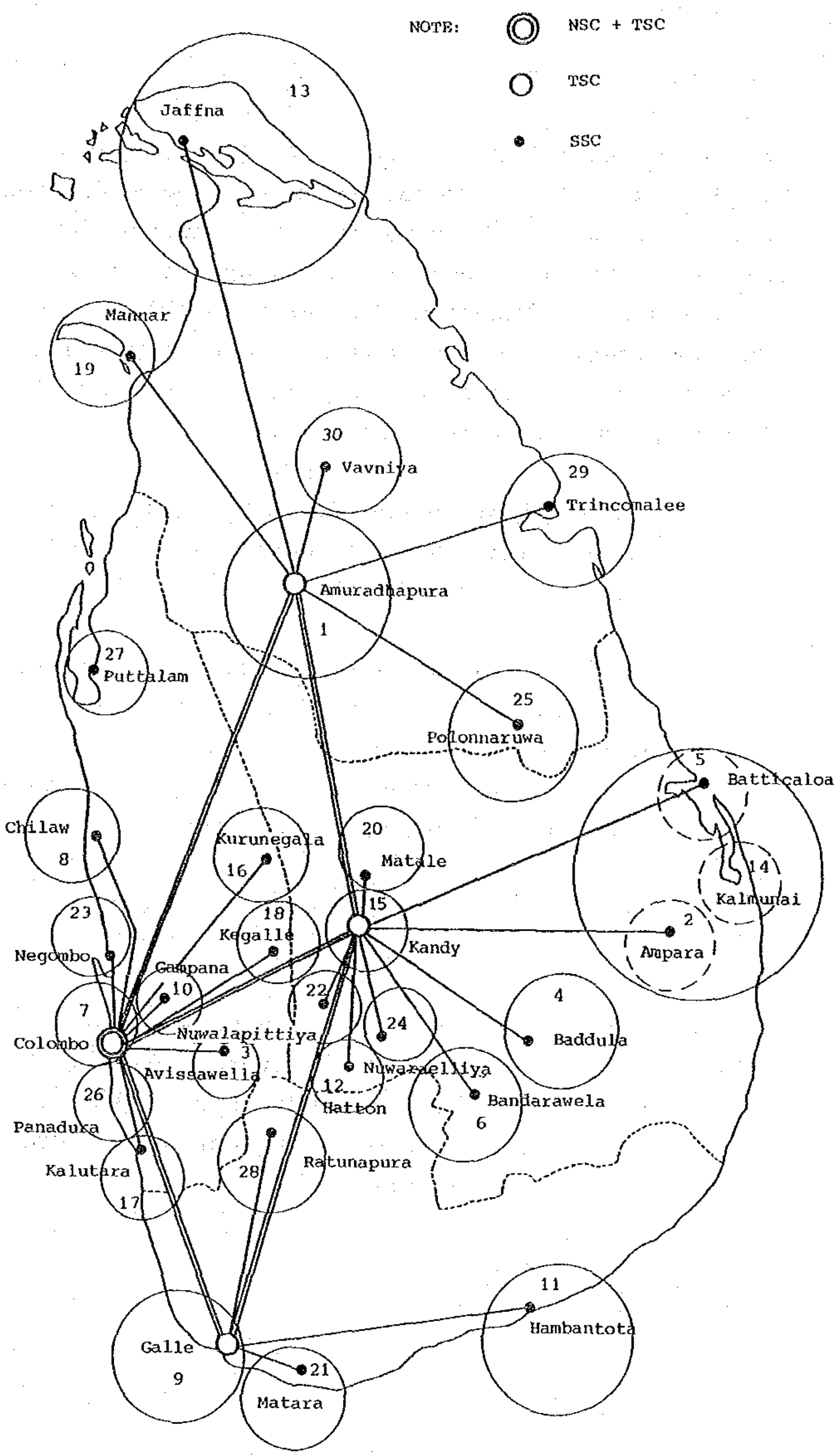
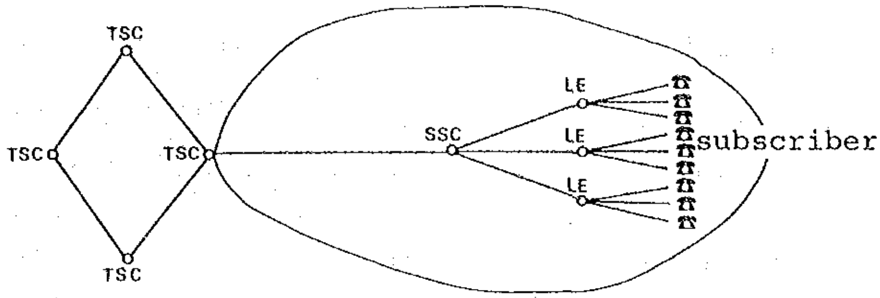


Figure 8-1 Project Unit Location Map



Project Unit

Project units, when formed on the basis of SSC, number 30. Three exchanges, i.e., Batticaloa, Kalmunai and Amparai, are grouped together in one project unit because they (1) use the same TSC-SSC circuit, (2) are mutually contiguous, (3) are small exchanges, and (4) hold the same rural exchange characteristics. As the result, 28 (30 minus 2 exchanges) independent projects are organized. Four TSCs are separated from project units because they are commonly used by all exchanges.

1.7 Alternative Planning Scales

Desirable future investment scale in telecommunications sector can be known from comparison of alternative planning scales. Conceivable for alternative planning scales are the following three:

(1) Tariff raise - Demand decrease

X) Speculative investment (investment beyond demand)

Y) Target attaining investment

(2) No tariff change - Normal demand growth

X) Speculative investment

Y) Target attaining investment

(3) Tariff cut - Demand spiral

X) Speculative investment

Y) Target attaining investment

X) speculative investment means positive investment. Especially X) in Category (3) is the most positive investment. This investment is not fit for Sri Lanka where the subscriber backlog already takes shape even at the existing tariff level, especially when financial availability plus project implementation and system management capabilities in the country are considered.

Y) target attaining investment is the kind of investment to fulfill 100% a certain amount of demand in the target year. This investment comprises various types, one differing from another in tariff rate (raise, no change or cut) and demand size relationship and in the choice of 1990, 2000 or 2010 as the target year for 100% demand fulfillment. This time, the foregoing Category (2), i.e., no tariff change - normal demand growth - 100% demand fulfillment in the year 2000, is used as the basic plan. And, by increase/decrease of revenue or benefits and increase/decrease of cost or expenditure, study is made concerning alternative worthiness of Category (1) - Y) and Category (3) - Y). Reasons for using Category (2) - X) only as the basic plan are these:

- Telecommunications project is composed of nationwide network
- The number of projects, this time, is as many as 30, necessitating complicated calculations.

Table 8-1 National Telephone Demand by Years (Basic Plan)

	No. of Exis. Tel	Additional	Cumulative Total
1983	73,425		
1986	147,806	28,466	28,466
1987	176,272	28,466	56,932
1988	204,738	28,466	85,398
1989	233,204	28,466	113,864
1990	261,670	28,466	142,330
1991	319,978	58,308	200,638
1992	378,286	58,308	258,946
1993	436,594	58,308	317,254
1994	494,902	58,308	375,562
1995	553,210	58,308	433,870
1996	658,682	105,472	539,342
1997	764,154	105,472	644,814
1998	869,626	105,472	750,286
1999	975,098	105,472	855,758
2000	1,080,570	105,472	961,230

2. FINANCIAL COST ANALYSIS

2.1 Cost Classification

For project IERR calculation, benefits data and cost data are necessary. Here, cost data are produced. Cost items are the following three:

(1) Installation Cost

- o Local switching equipment cost
- o Local line equipment (including junction circuit) cost
- o TSC-SSC toll switching and transmission line equipment cost
- o TSC-TSC transmission line equipment cost

(2) Maintenance Cost

(3) Operation Management Cost

2.2 Financial Cost Calculation

Cost calculations are based on preconditions. They are:

(1) For switching equipment installation and circuit construction, work period is assumed to be two years. Cost requirement is divided into 60% for initial year and 40% for second year.

(2) For switching equipment, local currency and foreign currency cost ratios are set at 15% and 85%,

respectively. For local cables, local currency and foreign currency cost ratios are set at 24% and 76%, respectively. Others are pursuant to Chapter 7 provisions.

(3) Phase II and Phase III are respectively divided into five years, and annual investment is to be made on equal terms.

(4) Operation management cost is set at 30% of operating revenue for Phase I, 25% for Phase II and 20% for Phase III. Although calculation based on cost-revenue interlinking is not appropriate for IRR calculation, 20% - 30% used in the calculation empirically proves to be reasonable. (Personnel and non-personnel cost ratio is 70:30)

(5) TSC-TSC transmission line equipment cost is distributed to project units according to their respective call traffic.

(6) Conversion into Rupees of equipment cost estimates in U.S. dollars is by the exchange rate of US$1 = 26 Rupees as of the time of survey.

(7) Maintenance cost estimate is calculated by empirical ratios to switching equipment, cable and transmission/radio equipment costs. Ratios used are us under.

- o Switching equipment:
  7% of installation cost

- o Outside plant:
  4% of construction cost

o Transmission/radio equipment:
5% of installation cost

To facilitate calculations, the average maintenance cost ratios by years for the above three items, shown in Table 8-2, are used. The mean ratio is about 5%. For Phase II and Phase III, wherein switching equipment investment cost ratio decreases compared with Phase I, the said mean ratio drops to 4% level. (Generally, personnel and non-personnel cost ratios are 80% and 20%, respectively.)

Maintenance cost becomes necessary, beginning the year after equipment installation and continuing throughout equipment service life of 20 years.

Table 8-2 Average Maintenance Cost Comparison by Years (in Market Price)

(Unit: US Dollar)

	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
(Actual Cost) $																
Switching Equip.		14,827,200	18,138,400	13,294,720	14,796,560	14,053,520	24,284,640	19,183,040	"	"	"	31,850,400	"	"	"	"
Circuits Local		11,700,000	15,330,000	20,110,000	21,100,000	16,090,000	37,133,400	35,969,400	"	"	"	64,950,000	"	"	"	"
Toll		4,670,600	5,877,300	3,832,700	3,176,000	4,581,700	7,277,640	"	"	"	"	16,412,960	"	"	"	"
Common Expense (TSC-TSC)				667,099	293,204		719,212	"	"	"	"	698,160	"	"	"	"
Total		31,197,800	39,345,700	37,904,519	39,365,764	34,725,220	69,414,892	63,149,292	"	"	"	113,911,520	"	"	"	"
(Ratio)																
Switching Equip.		47.5	46.1	35.1	37.6	40.5	35.0	30.4	"	"	"	28.0	"	"	"	"
Circuits Local		37.5	39.0	53.0	53.6	46.3	53.5	57.0	"	"	"	57.0	"	"	"	"
Toll		15.0	14.9	10.1	8.1	13.2	10.5	11.5	"	"	"	14.4	"	"	"	"
Common Expense (TSC-TSC)		0	0	1.8	0.7	0	1.0	1.1	"	"	"	0.6	"	"	"	"
Total		100.0	100.0	100.0	100.0	100.0	100.0	100.0	"	"	"	100.0	"	"	"	"
Switching Equip. x 7%		332.5	322.7	245.7	263.2	283.5	245.0	212.8	"	"	"	196.0	"	"	"	"
Total Circuits x 4%		210.0	215.6	252.4	246.8	238.0	256.0	274.0	"	"	"	285.6	"	"	"	"
Common Expense x 5%		0	0	9.0	3.5	0	5.0	5.5	"	"	"	3.0	"	"	"	"
Grand Total (%)		5.43	5.38	5.07	5.14	5.22	5.06	4.92	"	"	"	4.85	"	"	"	"

2.3 Financial Cost Breakdown

Financial cost breakdown is in Table 8-3. Phase by phase totals follow:

Phase I	5,851,100,000 Rupees
Phase II	13,818,500,000 Rupees
Phase III	28,528,300,000 Rupees

Phase II and Phase III totals are by far greater than Phase I total. This is because in Phase I, telephone demand fulfillment rate is not more than 75% or lower than in Phase II and Phase III, and also because the existing facilities and on-going projects can cater for demand to some extent.

In Phase I project cost, foreign currency and local currency component ratio is roughly 70:30. That is to say, foreign currency portion that occupies about 70% of the total is nearly equal to the case with on-going products of SLTD.

Table 8-4 presents cost breakdown by project units. Colombo Central holds major weight, occupying about 60% majority.

The foregoing financial cost constitutes the foundation of economic cost in economic analysis.

Table 8-3 Financial Cost of 30 Exchanges (in Rs 1,000)

	I					II					III				
	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Switching Equip.															
Local Currency	57,826	70,740	51,849	57,707	54,809	94,710	74,814	"	"	"	123,023	"	"	"	"
Foreign Currency	327,681	400,859	293,813	327,004	310,583	536,691	423,945	"	"	"	705,087	"	"	"	"
Local Cable															
Local Currency	73,008	95,654	125,476	131,664	100,412	231,712	224,432	"	"	"	405,288	"	"	"	"
Foreign Currency	231,192	302,926	397,384	416,936	317,928	733,772	710,762	"	"	"	1,283,412	"	"	"	"
Toll Circuits															
Local Currency	15,579	19,333	12,511	10,564	15,254	23,520	"	"	"	"	55,490	"	"	"	"
Foreign Currency	105,856	133,477	87,139	72,012	103,870	165,699	"	"	"	"	371,247	"	"	"	"
Main Circuits (among 4 TSCs)															
Local Currency	-	-	2,189	972	-	2,427	"	"	"	"	2,465	"	"	"	"
Foreign Curerncy	-	-	15,155	6,651	-	16,273	"	"	"	"	15,687	"	"	"	"
Sub-total															
Local Currency	146,413	185,727	192,025	200,907	170,475	352,369	325,193	"	"	"	586,266	"	"	"	"
Foreign cirrency	664,729	837,262	793,491	822,603	732,381	1,452,435	1,316,679	"	"	"	2,375,433	"	"	"	"
(Total)	811,143	1,022,988	985,519	1,023,510	902,856	1,804,786	1,641,882	"	"	"	2,961,699	"	"	"	"
Maintenance Cost (Foreign Currency)	-	45,697	102,882	154,780	209,359	257,551	352,386	463,325	520,263	604,202	688,141	837,185	986,229	1,135,270	1,284,320
Operation/Management Cost (Local Currency)	-	101,357	127,682	163,539	212,738	375,923	505,568	661,423	798,505	933,991	1,287,440	1,514,120	1,764,500	1,988,380	2,234,170
Grand Total	811,143	1,170,040	1,216,080	1,341,830	1,311,980	2,438,260	2,499,840	2,739,630	2,960,650	3,180,080	4,937,290	5,313,010	5,712,430	6,085,350	6,480,180
Total for Each Phase	5,851,073					13,818,460					28,528,260				

Table 8-4 (1/2) Investment Cost (in Rs 1,000)

		1986	1987	1988	1989	1990	1991	1992	1993
1	Anuradapura	0	0	9,857	652	0	12,232	12,232	12,232
2	Ampara	0	0	54	24	0	5,496	5,496	5,496
3	Avissawella	3,120	2,080	144	22,476	14,710	4,825	4,782	4,782
4	Badulla	4,680	3,120	206	37,315	16,819	17,227	17,227	17,227
5	Batticaloa	0	0	139,565	29,181	0	13,870	13,870	13,870
6	Bandarawela	3,900	2,600	163	30,726	11,536	13,071	13,071	13,071
7	Colomba	369,202	515,796	503,828	321,212	272,336	1,120,930	1,059,930	1,059,930
8	Chillaw	11,700	92,561	20,164	44	0	2,961	2,961	2,961
9	Galle	13,158	0	449	106,803	72,005	37,220	36,113	36,113
10	Gampaha	57,825	44,545	253	111	0	15,839	15,839	15,839
11	Hanbantota	0	0	132	58	0	5,893	5,893	5,893
12	Hatton	101,988	36,026	146	64	0	10,524	10,521	10,521
13	Jaffna	75,660	50,440	782	52,182	22,701	65,183	65,183	65,183
14	Kalmunai	0	0	142	73,860	27,348	7,748	7,718	7,718
15	Kandy	1,560	25,925	192,593	140,362	59,571	111,363	80,979	80,979
16	Kurunegala	0	0	376	165	55,710	37,378	23,359	23,359
17	Kulutara	0	0	324	63,669	41,413	18,995	18,995	18,995
18	Kegalle	0	0	140	1,195	753	11,272	11,272	11,272
19	Mannaar	3,580	5,720	64	8,609	27,560	15,253	12,341	12,341
20	Matale	780	520	210	92	72,038	24,853	14,898	14,898
21	Matara	151,970	55,099	302	133	507	30,252	30,252	30,252
22	Nawalapitiya	0	47,976	24,912	28	0	4,915	4,915	4,915
23	Negombo	0	0	654	99,091	63,319	59,093	59,093	59,093
24	Nuwara Eliya	5,460	3,640	217	95	12,517	44,736	36,857	36,857
25	Polonnaruwa	0	0	57	25	9,989	17,369	17,369	17,369
26	Panadura	0	67,823	34,328	115	0	13,501	13,501	13,501
27	Puttalam	1,560	10,040	62	27	79,063	22,687	307	307
28	Ratnapura	0	0	34,976	20,634	0	19,913	19,913	19,913
29	Trincomalee	0	0	13,019	8,646	29,992	28,236	15,024	15,024
30	Vavuniya	0	68,078	7,388	47	0	11,943	11,943	11,943
31	Total	811,143	1,022,990	985,518	1,023,510	889,888	1,804,790	1,641,880	1,641,880

Table 8-4 (2/2) Investment Cost (in Rs 1,000)

		1994	1995	1996	1997	1998	1999	2000
1	Anuradapura	12,232	12,232	25,343	25,343	25,343	25,343	25,343
2	Ampara	5,496	5,496	12,354	12,354	12,354	12,354	12,354
3	Avissawella	4,782	4,782	18,103	18,103	18,103	18,103	18,103
4	Badulla	17,227	17,227	26,871	26,871	26,871	26,871	26,871
5	Batticaloa	13,870	13,870	24,239	24,239	24,239	24,239	24,239
6	Bandarawela	13,071	13,071	22,426	22,426	22,426	22,426	22,426
7	Colomba	1,059,930	1,059,930	1,880,630	1,880,630	1,880,630	1,880,630	1,880,630
8	Chillaw	2,961	2,961	11,726	11,726	11,726	11,726	11,726
9	Galle	36,113	36,113	76,992	76,992	76,992	76,992	76,992
10	Gampaha	15,839	15,839	29,359	29,359	29,359	29,359	29,359
11	Hanbantota	5,893	5,893	19,632	19,632	19,632	19,632	19,632
12	Hatton	10,524	10,524	19,130	19,130	19,130	19,130	19,130
13	Jaffna	65,183	65,183	126,970	126,970	126,970	126,970	126,970
14	Kalmunai	7,748	7,748	20,696	20,696	20,696	20,696	20,696
15	Kandy	80,979	80,979	206,534	206,534	206,534	206,534	206,534
16	Kurunegala	23,359	23,359	43,443	43,443	43,443	43,443	43,443
17	Kulutara	18,995	18,995	35,559	35,559	35,559	35,559	35,559
18	Kegalle	11,272	11,272	16,133	16,133	16,133	16,133	16,133
19	Mannaar	12,3471	12,3471	6,137	6,137	6,137	6,137	6,137
20	Matale	14,808	14,808	24,129	24,129	24,129	24,129	24,129
21	Matara	30,252	30,252	42,533	42,533	42,533	42,533	42,533
22	Nawalapitiya	4,915	4,915	7,523	7,523	7,523	7,523	7,523
23	Negombo	59,093	59,093	86,269	86,269	86,269	86,269	86,269
24	Nuwara Eliya	36,857	36,857	50,023	50,023	50,023	50,023	50,023
25	Polonnaruwa	17,369	17,369	8,154	8,154	8,154	8,154	8,154
26	Panadura	13,501	13,501	28,885	28,885	28,885	28,885	28,885
27	Puttalam	307	307	6,691	6,691	6,691	6,691	6,691
28	Ratnapura	19,913	19,913	35,278	35,278	35,278	35,278	35,278
29	Trincomalee	15,024	15,024	24,234	24,234	24,234	24,234	24,234
30	Vavuniya	11,943	11,943	25,712	25,712	25,712	25,712	25,712
31	Total	1,641,880	1,641,880	2,961,700	2,961,700	2,961,700	2,961,700	2,961,700

3. ECONOMIC COST ANALYSIS

3.1 Economic Cost Calculation Method

Project cost estimated in Section 2.2 (which is the market cost) cannot be used intact for IERR calculation. Reasons are:

(1) The cost includes that of other resources than for project implementation in a true sense.

(2) Price of resources to be used does not indicate the real worth of those resources.

Cost components which come under Category (1) include taxes and interest on loan. For Category (2), especially noteworthy are that the exchange rate applicable to foreign currency does not exactly indicate the real worth of the Rupee so that the conversion into Rupees of the value of imported goods is not accurate, and that the cost of unskilled labor consists of wages not compatible with labor productivity.

3.2 Method of Re-evaluation in Rupees of Imported Goods by Foreign Currency

According to Central Bank of Ceylon data, the Dollar-Rupee exchange rate varies as under. Variations reflect fluctuation under the floating rate system.

December 1982	21.32 Rupees
December 1983	25.00 Rupees
January 1985	26.00 Rupees

When, then, is the shadow exchange rate (otherwise called the standard conversion factor) of the Rupee to the Dollar in real terms? Is it 25 Rupees or 26 Rupees or even 30 Rupees? The economic value of currency, like that of tea and coffee, is determined by international market competitions. However, Rupee currency, unlike tea, for instance, cannot be exported by itself. Hence calculation of Rupee currency value from export and import competitive relationship of the whole country and from export and import duties correlation which exerts influence on export and import competitive relationship.

Correlation formula that governs the relationship between export and import, on one hand, and currency value, on the other, and calculation results by that correlation formula follow:

$$SCF = \frac{Im + Ex}{Im + Tm + Ex - Tx}$$

Table 8-5 SER Calculations

(in million Rupees)

	Gross Import Amount (Im) (CIF Price)	Gross Export Amount (Ex) (FOB Price)	Import Duties (Tm)	Export Duties (Tx)	Standard Conversion Factor (SCF)
1978	15,100	13,193	1,469	4,236	1.108
1979	22,603	15,282	2,271	4,168	1.053
1980	33,652	17,799	2,924	3,638	1.014
1981	35,251	20,585	3,226	3,685	1.008
1982	41,946	21,454	3,222	2,484	0.988
1983	45,553	25,096	4,896	2,604	0.969

Source: Customs Returns, Dept. of Census and Statistics

3.3 Shadow Exchange Rated Calculation

Calculation results indicate that the international market value of Rupee currency is on downtrend. As of 1983, SCF stands at 26.8 Rupees, or, more precisely:

$$26 \text{ Rupees} \times \frac{1}{0.969} = 26.8$$

External trade balance of Sri Lanka is chronically in the deficit so that 26.8 appearing above is raised to 27 instead of being reduced to 26.

From the foregoing, US$1 = 27 Rupees exchange rate is used in economic cost calculation by means of conversion of necessary foreign currency budget for project implementation into Rupee equivalent.

Goods procured by local currency (otherwise defined as non-foreign trade goods or domestic products) actually include foreign trade goods. Towers of Sri Lanka make provide one example. Some of tower parts, e.g., iron, are of overseas origin. Thus, for imported iron cost calculation also, SCF should of course be used. This time, however, imported iron cost calculation by SCF is omitted because the objective is not feasibility study but master plan formulation.

(Note: SCF is a terminology which is used for conversion of foreign trade goods value into Rupee equivalent. Shadow Exchange Rate is a terminology which is used to indicate the exchange value of Rupee currency. The working theory is common to both.)

3.4 Shadow Labor Cost Philosophy

In telecommunications project, labor requirement at the stage of facilities construction consists of skilled labor up to 30% and unskilled labor to the extent of 70%. At the stages of system maintenance, operation and management, the absolute majority of 99% consists of skilled labor.

In Sri Lanka, skilled labor is deficient. Thus, for employment of skilled labor, market mechanism functions so that worth of labor and market wage mutually agree.

For unskilled labor, wages depend upon labor union movement, degree of unemployment, and pertinent law provisions. Therefore, wages are not necessarily determined by marginal productivity of labor. For shadow wage rate applicable to unskilled labor, calculation is made, using the number of unemployed labor, which is considered to exert utmost influence on the amount of wage, as index.

3.5 Shadow Labor Cost Calculation

As of 1983, the national rate of unemployment in Sri Lanka stands at 17.9%. The rate of unemployment varies from area to area. When 24 prefectures and 246 villages are realigned to 30 project units, the unemployment rates by exchange areas are as shown in Table 8-6. From this table, unskilled labor cost is estimated, using [1 - rate of unemployment] as shadow wage rate.

Table 8-6 Rate of Unemployment (1983)

Exchange		Rate %	Exchange		Rate %
1	Anuradapura	8.6	16	Kurunegala	14.9
2	Ampara	13.6	17	Kulutara	25.3
3	Avissawella	20.1	18	Kegalle	25.1
4	Badulla	10.5	19	Mannar	3.0
5	Batticaloa	8.8	20	Matale	12.3
6	Bandarawela	10.7			
7	Colombo	21.5	21	Matara	27.3
8	Chillaw	10.7	22	Nawalapitiya	18.9
9	Galle	26.0	23	Negombo	18.4
10	Gampaha	26.1	24	Nuwara Eliya	8.5
			25	Polonnaruwa	13.9
11	Hambantota	18.6	26	Panadura	25.3
12	Hatton	8.5	27	Puttalam	10.7
13	Jaffna	14.1	28	Ratnapura	14.0
14	Kalmunai	11.2	29	Trincomalee	12.3
15	Kandy	18.9	30	Vavuniya	6.0

Source: Ministry of Plan Implementation, "The Economically Active Population", 1983.

3.6 Other Preconditions (Sunk Cost, Salvage Value)

Cost to be entailed on each project unit consists of cost pertaining to new investment. When new investment is made, existing towers, poles and exchange buildings are utilized in some cases. Cost of such existing facilitates is commonly called sunk cost. This time, sunk cost is not included in new project cost in the belief that it is already included in the past project cost.

Investment in new telephone facilities up to the year 2000 constitutes an important project item, this time. Usually, telephone facilities service life is 20 years. Therefore, assumption is made that new investment cost as of the year 2000 is to cover maintenance, operation and management costs for further 20 years, i.e., until 2020 while, on the other hand, service revenue at the level as of 2000 will continue for 20 more years. By this means, solution can be attained to salvage value problem pertaining to facilities cost.

3.7 Economic Cost Breakdown

By taking into account SCF and shadow labor cost described in Section 3.2 and Section 3.5, calculation is made for final economic cost. Calculation results are in Table 8-7. In Sri Lanka, influence from SCF and shadow labor cost is extremely small so that Phase I economic cost remains at a level of about 11% more than financial cost. In Phase II and Phase III, switching equipment investment wherein foreign currency ratio is high decreases so that the gap between economic cost and financial cost further diminishes.

	Financial Cost	Economic Cost
Phase I	5,851,073,000 Rupees	6,482,277,000 Rupees
Phase II	13,818,460,000 Rupees	13,847,810,000 Rupees
Phase III	28,528,260,000 Rupees	28,579,190,000 Rupees

Table 8-7 (1/2) Economic Cost (in Rs 1,000)

		1986	1987	1988	1989	1990	1991	1992	1993
1	Anuradapura	0	0	10,091	6,676	0	12,467	12,467	12,467
2	Ampara	0	0	55	24	0	5,579	5,579	5,579
3	Avissawella	3,106	2,072	146	22,552	14,757	4,792	4,792	4,792
4	Badulla	4,739	3,159	211	38,042	17,107	17,534	17,534	17,534
5	Batticaloa	0	0	142,937	29,761	0	14,140	14,140	14,140
6	Bandarawela	3,949	2,632	167	31,348	11,731	13,304	13,304	13,304
7	Colombo	371,126	517,260	503,751	321,135	272,127	1,121,540	1,060,220	1,060,220
8	Chillaw	11,845	94,689	20,612	46	0	3,010	3,010	3,010
9	Galle	10,789	0	454	106,252	74,638	37,011	35,897	35,897
10	Gampaha	60,049	44,421	257	112	0	15,732	15,732	15,732
11	Hanbantota	0	0	134	58	0	5,976	5,976	5,976
12	Hatton	104,344	36,773	156	65	0	10,723	10,723	10,723
13	Jaffna	76,056	50,704	799	53,120	23,076	65,868	65,868	65,868
14	Kalmunai	0	0	145	75,278	27,781	7,883	7,883	7,883
15	Kandy	1,556	26,275	192,887	140,607	60,230	112,102	81,322	81,322
16	Kurunegala	0	0	385	169	56,486	37,847	23,615	23,615
17	Kulutara	0	0	327	63,440	41,249	18,891	18,891	18,891
18	Kegalle	0	0	151	1,201	758	11,315	11,315	11,315
19	Mannar	8,790	5,860	66	8,819	28,233	15,692	12,705	12,705
20	Matale	786	523	214	95	74,808	25,200	15,080	15,080
21	Matara	152,304	54,892	304	134	510	30,116	30,116	30,116
22	Nawalipitiya	0	48,497	25,138	29	0	4,946	4,946	4,946
23	Negombo	0	0	665	99,420	63,493	59,410	59,410	59,410
24	Nuwara Eliya	5,541	3,694	223	98	12,807	45,899	37,783	37,783
25	Polonnaruwa	0	0	58	26	10,196	17,673	17,673	17,673
26	Panadura	0	67,864	34,239	116	0	13,403	13,403	13,403
27	Puttalam	1,597	1,053	64	28	80,685	23,165	314	314
28	Ratnapura	0	0	35,395	20,857	0	20,140	20,140	20,140
29	Trincomalee	0	0	13,269	8,812	30,506	28,717	15,261	15,261
30	Vavuniya	0	69,919	7,533	49	0	12,236	12,236	12,236
31	Total	816,577	1,030,290	990,833	1,028,370	898,178	1,812,320	1,647,340	1,647,340
	Maintenance Cost	0	45,697	102,882	154,780	209,359	257,551	352,386	436,325
	Operation/Management Cost	0	101,357	127,682	163,539	212,738	375,923	505,568	661,423
	Grand Total	816,577	1,777,340	1,221,400	1,346,690	1,320,270	2,445,790	2,505,290	2,745,090

Table 8-7 (2/2) Economic Cost (in Rs 1,000)

		1994	1995	1996	1997	1998	1999	2000
1	Anuradapura	12,467	12,467	25,798	25,798	25,798	25,798	25,798
2	Ampara	5,579	5,579	12,545	12,545	12,545	12,545	12,545
3	Avissawella	4,792	4,792	18,128	18,128	18,128	18,128	18,128
4	Badulla	17,534	17,534	27,344	27,344	27,344	27,344	27,344
5	Batticaloa	14,140	14,140	24,682	24,682	24,682	24,682	24,682
6	Bandarawela	13,304	13,304	22,797	22,797	22,797	22,797	22,797
7	Colombo	1,060,220	1,060,220	1,883,650	1,883,650	1,883,650	1,883,650	1,883,650
8	Chillaw	3,010	3,010	11,941	11,941	11,941	11,941	11,941
9	Galle	35,897	35,897	76,499	76,499	76,499	76,499	76,499
10	Gampaha	15,732	15,732	29,147	29,147	29,147	29,147	29,147
11	Hanbantota	5,976	5,976	19,771	19,771	19,771	19,771	19,771
12	Hatton	10,723	10,723	19,482	19,482	19,482	19,482	19,482
13	Jaffna	65,868	65,868	128,266	128,266	128,266	128,266	128,266
14	Kalmunai	7,883	7,883	20,980	20,980	20,980	20,980	20,980
15	Kandy	81,322	81,322	207,023	207,023	207,023	207,023	207,023
16	Kurunegala	23,615	23,615	43,853	43,853	43,853	43,853	43,853
17	Kulutara	18,891	18,891	35,299	35,299	35,299	35,299	35,299
18	Kegalle	11,315	11,315	16,047	16,047	16,047	16,047	16,047
19	Mannar	12,705	12,705	6,301	6,301	6,301	6,301	6,301
20	Matale	15,080	15,080	24,410	24,410	24,410	24,410	24,410
21	Matara	30,116	30,116	42,291	42,291	42,291	42,291	42,291
22	Nawalipitiya	4,946	4,946	7,562	7,562	7,562	7,562	7,562
23.	Negombo	59,410	59,410	86,632	86,632	86,632	86,632	86,632
24	Nuwara Eliya	37,783	37,783	51,153	51,153	51,153	51,153	51,153
25	Polonnaruwa	17,673	17,673	8,244	8,244	8,244	8,244	8,244
26	Panadura	13,403	13,403	28,654	28,654	28,654	28,654	28,654
27	Puttalam	314	314	6,806	6,806	6,806	6,806	6,806
28	Ratnapura	20,140	20,140	35,632	35,632	35,632	35,632	35,632
29	Trincomalee	15,261	15,261	24,595	24,595	24,595	24,595	24,595
30	Vavuniya	12,236	12,236	26,361	26,361	26,361	26,361	26,361
31	Total	1,647,340	1,647,340	2,971,890	2,971,890	2,971,890	2,971,890	2,971,890
	Maintenance Cost	520,263	604,202	688,141	837,185	986,229	1,135,270	1,284,320
	Operation/Management Cost	798,505	933,991	1,287,440	1,514,120	1,764,500	1,988,380	2,234,170
	Grand Total	2,966,110	3,185,530	4,947,470	5,323,190	5,722,620	6,095,540	6,490,370

4. BENEFITS ANALYSIS

4.1 Philosophy of Benefits

Benefits arising out of investment in telecommunications project are mainly twofold. One is in "with" aspect and the other in "without" aspect. The former is the increased production benefits resulting from rapid transmission of information, represented by effective inventory management. The latter is the loss prevention benefits as seen in the curtailment of cost of mails and telegrams, so far the principal means of communication.

For those benefits, however, physical calculation is not possible. Here, benefits calculation is made, based on service revenue from telecommunications project investment. That is to say, calculation is made for service revenue plus consumer's surplus as benefits.

4.2 Types of Benefits

Benefits are classified as under.

(1) Subscription Charge

This charge is equipment charge and is collected once only from each new subscriber.

(2) Standing Charge

This charge consists of a fixed amount and is collected annually from each subscriber.

(3) Local Call Charge

This charge is collected from subscribers, based on their originating traffic inside the exchange area to which they belong.

(4) Toll Call Charge

This charge is on calls from one exchange area to another and is collected, based on call distance and calling hours (day-time/night-time).

(5) International Call Charge

This charge is on calls to foreign countries.

(6) Consumer's Surplus

The fact that subscriber backlog arises at the existing level of service charge signifies that benefits in excess of service charge exist. Such benefits are defined as consumer's surplus.

(7) Network Effect

Capacity expansion at other exchanges by the project concerned, i.e., subscriber increases, causes originating traffic from other exchanges (terminating traffic to this exchange) to increase.

Actually, call charge is paid by the calling party only. However, call charge mentioned here does imply the combined benefits of both calling and called parties. In other words, transmission of information in a real sense takes effect only when transmission and reception function as one entity.

As for induced toll call increases as network effect, as mentioned in Item (7) above, such traffic is assumed to be included in national demand estimate. Hence exclusion from benefits calculation, this time.

Telecommunications services comprise many other services than subscriber telephone service, such as public telephone, telex, leased circuit and telegram services. These latter service categories also create service revenue and, depending upon demand size, necessitate investment for service expansion, accompanied by investment cost accrual. This time, however, considering that more than 90% of demand is for subscriber telephones, benefits analysis is made for subscriber telephone service only.

4.3 Benefits Distribution Idiosyncrasy

For evaluation of project benefits, especially telephone charge revenue, the prime requisite is to estimate such benefits as deriving from new project as a whole.

Telecommunications system architecture is three-dimensional. It is composed of a plural number of telephone exchanges of different office hierarchies. For this reason, investment plan for telecommunications system is usually made for individual system components (local/toll switching equipment, local line equipment, toll/trunk circuits, etc.), based on separate demand forecasts or traffic forecasts. Plan for one system component is implemented separately from plan for another system component.

In other words, telecommunications project, unlike highway or dam construction project, is seldom or never executed by a single investment covering the whole system. Therefore, fair and just evaluation of real benefits arising out of new telecommunications project is not easy. Furthermore, the problem involved becomes all the more complicated when the network to be completed by the project is of large scale as in the present case of Master Plan formulation.

This problem can after all be dealt with as analogous concept to sunk cost referred to in Section 3.6. Therefore, in this report, service revenue correction is made by the undermentioned approach.

4.4 Benefits Distribution by Cost Component Ratio

First, cost ratios by telecommunications system components, worked out by World Bank consultant as survey result, are used. Suppose, for instance, that equipment is in local switching equipment only. Then, from Table 8-8, the corresponding revenue can be estimated at gross revenue x 0.25.

Table 8-8 Cost Ratios by System Components

System Component	Cost Ratio (%)
Subscriber's premise equipment	10
Local subscriber's cable	35
Local switching equipment	25
Local inter-office junction equipment	10
Toll switching equipment	5
Toll transmission equipment	15

Annual service revenue estimated from demand forecast or traffic forecast is multiplied by individual benefits ratios calculated from Table 8-8 which are applicable to existing facilities in each project unit plus on-going projects including IDA project. By this means, benefits arising out of new project are identified.

For Colombo Central, above benefits ratios are not used. Instead, calculated benefits minus benefits estimated in Greater Colombo Area Project feasibility study are applied.

4.5 Tariff Elasticity

To what extent is the demand volume or service revenue influenced by tariff raise or reduction? This is an important study item in benefits calculation. The answer is given by tariff elasticity analysis. In Sri Lanka where the number of telephone applicants is so large that subscriber backlog as of 1985 may probably be upwards of 50%, tariff elasticity is low. In other words, a more or less tariff raise is not considered to touch off an abrupt decrease in the number of telephone applicants. Nevertheless, elasticity planning is not feasible. This time, by setting elasticity value at 1, the degree of its influence is examined by sensitivity analysis.

4.6 Tariff System

Telecommunications service tariffs to be used in Master Plan appear in Table 8-9. Those tariffs are assumed to remain effective from 1986 through 2020. The reason is as under.

Although future tariff raise can of course be considered, the fact is that all costs and benefits are estimated at price level as of 1986 and are adjusted to present worth. Thus, for service tariffs, the unit price is to remain fixed, and, for benefits, calculation is made where necessary according to future demand size.

Table 8-9 Telecommunication Tariffs (1/2)

(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

(4) Long Distance Calls

(a) Directly Dialed STD

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

Table 8-9 Telecommunication Tariffs (2/2)

(As of December, 1984)

(b) International Calls

Station to Station Call to:	Directly Dialed	Operator Connected	
	Per minute	First 3 minutes	Every additional 3 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

4.7 Installation Fee Revenue

Installation fee is chargeable only once to each new subscriber. The rate is 7,000 Rupees. (See note below.) Annual total of installation fee is calculated by

Number of newly installed telephones x 7,000 Rupees

The number of newly installed telephones is calculated as under by straight interpolation from demand fulfillment ratios as of 1985, 1990, 1995 and 2000 estimated in Chapter 4 and exchange by exchange demand forecasts.

(1) 1986 - 1990

$$\text{Installation Fee} = \frac{D_{1990} \times 0.85 - D_{1985} \times 0.75}{5} \times 7{,}000 \text{ (Rupee/year)}$$

(2) 1991 - 1995

$$\text{Installation Fee} = \frac{D_{1995} \times 0.95 - D_{1990} \times 0.85}{5} \times 7{,}000 \text{ (Rupee/year)}$$

(3) 1996 - 2000

$$\text{Installation Fee} = \frac{D_{2000} \times 1.0 - D_{1995} \times 0.95}{5} \times 7{,}000 \text{ (Rupee/year)}$$

where D_i denotes demand for telephones in the year i.

Installation fee revenue calculated by the foregoing is in Table 8-11.

Note: At Colombo Central, Mattakkuliya, Maradana and Haverlock Town exchanges in Colombo SSC area, installation fee is 10,000 Rupees/subscriber.

4.8 Annual Rental Revenue

Annual rental is chargeable annually to each subscriber for existing telephone. The rates are

For office telephone: 900 Rupees/telephone/year
For residence telephone: 360 Rupees/telephone/year

The ratio between office telephones and residence telephones in the number installed varies from exchange to exchange. This time, based on Greater Colombo Area Project feasibility study results (1983), assumptions are made as under.

(1) At three exchanges in Colombo SSC area, i.e., Colombo Central, Mattakkuliya and Maradana.

No. of office telephones : No. of residence telephones = 7 : 3

Average annual rental charge:

900 x 0.7 + 360 x 0.3 = 738 (Rupee/telephone/year)

(2) At other exchanges than above

No. of office telephones : No. of residence telephones = 3 : 7

Average annual rental charge:

900 x 0.3 + 360 x 0.7 = 522 (Rupee/telephone/year)

For annual rental revenue, calculation is made with the average annual rental obtained as per above multiplied by the cumulative total of newly installed telephones since 1986, and finally taking the benefits ratio into consideration. Calculation results are in Table 8-11.

4.9 Call Charge

Call charges are fourfold. They are

(1) Local call charge
(2) Local trunk call charge (in Colombo SSC area)
(3) Toll call charge
(4) International call charge

For each call charge category, calculation is made, based on exchange by exchange busy hour originating traffic estimate as per Chapter 4. First, busy hour originating traffic is divided by concentration rate to obtain traffic per day. Then, division by mean holding time of successful calls is made to obtain average number of calls per day.

Finally, multiplication by call completion rate, annual mean of working days and revenue per complete call is made to obtain annual call charge revenue. Basic formula of calculation is

$$YR = \frac{\frac{BT}{BCR}}{MT} \times CR \times RC \times WD \quad \ldots\ldots\ldots\ldots\ldots \quad (8\text{-}1)$$

For variables, the values used in Greater Colombo Area Project feasibility study are applied after partial modification as in Table 8-10.

Table 8-10 Prices Used in Revenue Calculation

Variable	Contents	Local, Local Trunk Calls	Toll Calls	International Calls
YR	Yearly revenue	-	-	-
BT	Busy hour originating traffic (Erl)	-	-	-
BCR	Busy hour concentration rate	10 (%)	10 (%)	10 (%)
MT	Mean holding time (Mean holding time of complete call)	145 (s) (135)	265 (s) (250)	470 (s) (30)
CR	Call completion rate	0.5	0.5	0.6
WD	No. of working days	280	280	280
RC	Revenue per complete call	Local: 1.44 (RPS) Local Trunk: 1.70 (RPS)	11.9 (RPS)	130 (RPS)

(1) Local Call Charge

By substituting Table 8-10 values in Formula (8-1), calculation formulas for annual local call charge revenue and annual local trunk call charge revenue can be obtained.

Local call charge revenue =
$50{,}050 \times BT_L$ (Rupee/year) .... (8-2)

Local trunk call charge revenue =
$60{,}060 \times BT_J$ (Rupee/year) .... (8-3)

where

BT_L: Busy hour local originating traffic

BT_J: Busy hour local trunk originating traffic

For local call charge per call, calculation is made on the assumption that out of all local calls, 40% are less than 120 seconds calls and 60% are 120-240 seconds calls because mean holding time of complete call is 135 seconds and charge is 0.9 Rupees/120 seconds. Local trunk call charge per call is assumed to the 1.2 times local call charge per call because call duration per 0.9 Rupees is reduced to 100 seconds.

(2) Toll Call Charge

Annual toll call charge revenue is calculated by Formula (8-1) and Table 8-10 values as in the case of annual local call charge revenue.

Toll call charge revenue =
$226{,}000 \times BT_T$ (Rupee/year) .... (8-4)

where

BT_T: Busy hour toll originating traffic

Toll call charge per call is calculated in the mean value in consideration of night-time discount rate and charge differentiation by distance.

(3) International Call Charge

Annual international call charge revenue is calculated in the same way as in the preceding (1) and (2) cases. That is,

International call charge revenue =
1,415,000 x BT_I (Rupee/year) .... (8-5)

where

BT_I: Busy hour international originating traffic

At the present stage, international call traffic situation of other exchanges than Colombo Central is not certain. In Greater Colombo Area Project feasibility study, international call traffic share of Colombo Central is estimated at 4.94% and average share of other exchanges in Colombo SSC area at 0.95%. Therefore, this time also, international call traffic ratio at other exchanges than Colombo Central in Colombo SSC area is assumed to be 0.95%. This ratio signifies that international call charge revenue corresponds to 8.5% of toll call charge revenue.

For use of international telephone circuits, SLTD must pay 29 Rupees/minute as rental. This fact is taken into account in the foregoing Formula (8-5).

Call charges calculated for the above items (1), (2) and (3) are finally multiplied by exchange by exchange benefits ratios. Results obtained are in Table 8-11.

4.10 Consumer's Surplus Philosophy

Refer to Figure 8-2.

Assume that the present supply volume is OS and installation volume OP. Demand-supply position is shown by OD wherein subscriber backlog BC exists. When supply curve is moved from S to S' to eliminate subscriber backlog by expansion plan, demand and supply are balanced at B on condition that installation fee remains unchanged. Demand curve indicates the maximum of all amounts which subscriber applicants are willing pay for the number of telephones available.

Here is an example. For OS, the consumer is willing to pay installation fee of OR. However, the actual installation is OP. The balance PR can be considered to be premium for telephone installation. In other words, when the backlog BC exists, the consumer who wants to have his telephone by all means has to pay installation fee OR plus premium PR. Only when BC is satisfied, premium PR becomes O.

The corollary is that in the comparison between before and after the expansion, the area occupied by triangle ABC represents the socially considered increment of benefits, i.e., consumer's surplus.

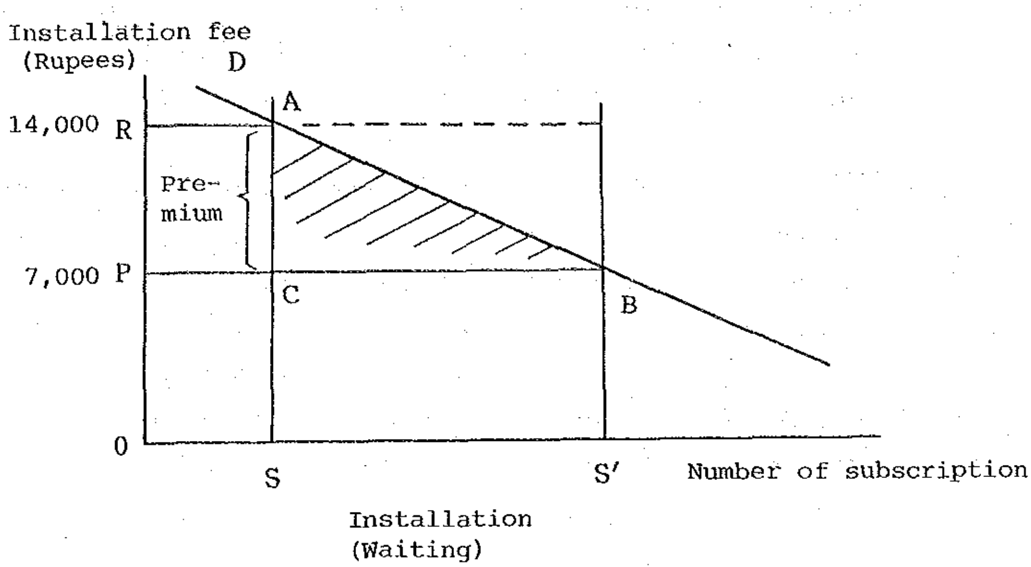


Figure 8-2 Consumer's Surplus for Installation Fee

4.11 Consumer's Surplus Calculation

For installation fee, consumer's surplus takes shape as premium. For call charge, consumer's surplus depends upon the degree of user's willingness to pay.

(1) Consumer's surplus pursuant to telephone subscription is expressed by

Subscriber backlog x 7,000 Rupees x 1/2

As previously mentioned, installation fee is 10,000 Rupees in Colombo Central Central exchange area and 7,000 Rupees in other exchange areas. In Greater Colombo Area Project feasibility study, premium is valued at 10,000 Rupees. In the nationwide Master Plan to be formulated, this time, premium in local areas in presumed to be lower valued than in Colombo. Hence the use of uniform 7,000 Rupees for the whole country. Furthermore, consumer's surplus shown in Figure 8-2, insofar as the marginal growth in the number of telephones installed (i.e., subscriber backlog decrease) is concerned.

(2) Consumer's surplus pertaining to telephone speech cannot be exactly calculated. Actually, as telephone diffusion progresses and demand fulfillment reaches 100%, consumer's surplus vis-a-vis telephone speech is considered to become minimum. In other words, the lower the degree of demand fulfillment and the higher the degree of subscriber backlog, the greater the consumer's surplus.

This time, 15% of service charge revenue is set aside as consumer's surplus. The reasonableness of this arrangement is proven by sensitivity analysis.

4.12 Gross Benefits Estimate

Year by year breakdown of incremental revenue plus consumer's surplus is in Table 8-11. Installation fee revenue first appears in 1987 and can be expected until 2000. Meanwhile, as of the year 2000, installation fee benefits stand at 10% of gross benefits, annual rental benefits at 5%, call charge benefits at 74% and consumer's surplus benefits at 11%.

In value, installation fee benefits amount to 846,000,000 Rupees, annual rentals benefits to 449,000,000 Rupees, call charge benefits to 6,152,000,000 Rupees and consumer's surplus benefits to 922,000,000 Rupees. Gross revenue totals 7,447,000,000 Rupees and gross benefits aggregate 8,370,000,000 Rupees.

Table 8-11 Breakdown of Incremental Revenue (in Rs 1,000)

	Year	Installation Charge	Annual Rentals	Call Charge	Consumer's Surplus	Benefits (E)	Gross Benefits (F)
I	1986	0	0	0	0	0	0
	1987	157,303	10,683	169,870	170,199	508,056	337,857
	1988	119,303	17,824	288,479	193,593	619,199	25,606
	1989	126,820	24,813	393,499	215,013	760,144	545,131
	1990	148,477	33,212	527,437	239,470	948,596	709,126
II	1991	370,649	56,439	825,987	272,150	1,525,230	1,253,080
	1992	408,489	84,592	1,192,150	317,710	2,002,940	1,685,230
	1993	464,622	112,352	1,627,770	374,260	2,579,000	2,204,740
	1994	464,622	139,789	2,057,270	429,400	3,091,080	2,661,680
	1995	464,622	166,951	2,481,730	483,770	3,597,070	3,113,300
III	1996	844,149	223,944	3,223,390	584,810	4,876,290	4,291,480
	1997	846,096	280,834	3,920,140	664,170	5,711,240	5,047,070
	1998	846,096	337,274	4,698,300	755,510	6,637,180	5,881,670
	1999	846,096	393,319	5,388,520	833,660	7,461,600	6,627,940
	2000	846,096	449,014	6,152,110	922,820	8,370,040	7,447,220
	2001	0	449,014	6,152,110	122,820	7,523,940	6,601,120
	2002	0	449,014	6,152,110	122,820	7,523,940	6,601,120
	2003	0	449,014	6,152,110	122,820	7,523,940	6,601,120
	2004	0	449,014	6,152,110	122,820	7,523,940	6,601,120
	2005	0	449,014	6,152,110	122,820	7,523,940	6,601,120
	2006	0	449,014	6,152,110	122,820	7,523,940	6,601,120
	2007	0	449,014	6,152,110	122,820	7,523,940	6,601,120
	2008	0	449,014	6,152,110	122,820	7,523,940	6,601,120
	2009	0	449,014	6,152,110	122,820	7,523,940	6,601,120
	2010	0	449,014	6,152,110	122,820	7,523,940	6,601,120
	2011	0	372,683	5,106,270	765,940	6,244,890	5,478,950
	2012	0	372,683	5,106,270	765,940	6,244,890	5,478,950
	2013	0	372,683	5,106,270	765,940	6,244,890	5,478,950
	2014	0	372,683	5,106,270	765,940	6,244,890	5,478,950
	2015	0	372,683	5,106,270	765,940	6,244,890	5,478,950
	2016	0	238,074	3,261,940	489,290	3,989,300	3,500,010
	2017	0	238,074	3,261,940	489,290	3,989,300	3,500,010
	2018	0	238,074	3,261,940	489,290	3,989,300	3,500,010
	2019	0	238,074	3,261,940	489,290	3,989,300	3,500,010
	2020	0	238,074	3,261,940	489,290	3,989,300	3,500,010