CHAPTER III

4

4. Circuit Requirement

4.1 Operations of Multiple Gateways and Diversification of Transmission Routes

From the standpoint of maintaining the continuity of telecommunication services even when a gateway facilities fails, as many destinations as possible should be distributed to multiple gateway stations in making a circuit plan. International and domestic transmission routes should also be diversified to disperse risks and to avoid double hop connection. In case international traffic is routed through PALAPA satellite, the international portion had better been handled by cables.

An overall judgement, however, will be needed in making a circuit plan after carefully considering other factors such as economic efficiency, (e.g., a circuit division loss), and increase in utilization caused by enhanced services.

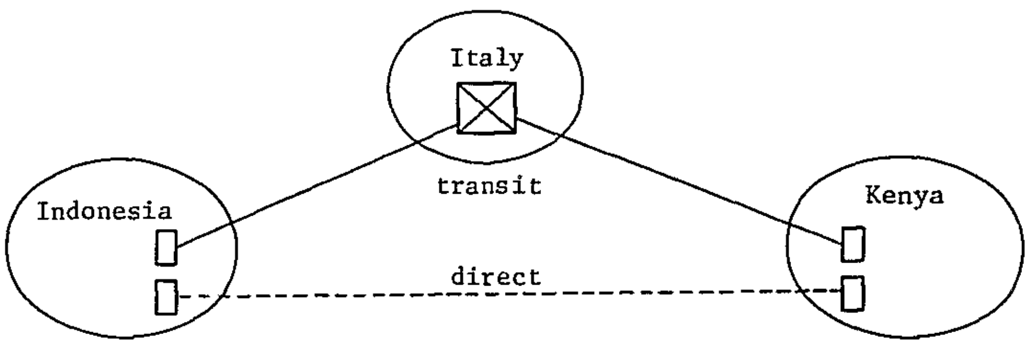
The opening of the Medan office seems to be justifiable for P.T. Indosat in view of the advantage it offers in enhancing services to users in Sumatra. In this connection, traffic to and from Sumatra should be basically handled by the Medan Gateway Office, while traffic of other regions should be handled by the Jakarta Gateway Office judging from the current state of domestic transmission lines and other factors. A natural reasoning implies that the Jakarta office will handle only the traffic to and from Sumatra with destinations which are not accommodated by the Medan Office.

In reality, however, the cooperation of not only PERUMTEL but also other parties in foreign countries has to be secured to build multiple gateway offices.

4.2 Break-Even Analysis for Direct and Transit Routes

When setting international circuits, it is desirable to maintain direct circuits with all the countries if at all possible, from the standpoint of national interests. For telecommunication reliability as well, an excessive dependence on a particular transit point is not desirable. However, the facility redundancy, economy, intentions of the other countries, and other factors have to be considered as the important factors when setting direct circuits. This Section studies the economic aspect for direct and transit circuit particularly in terms of break-even analysis.

First, let us assume that P.T. Indosat has started studying whether or not direct telephone circuit should be established with a country, for example Kenya. Let us further assume that the traffic with that country is currently handled via a third country, Italy in this instance.



Under current international customs and practices, telecommunication rates do not differ between direct and transit routes, and there can be no difference in revenue of terminating countries. This means that only expenditures, namely cost, should be compared between direct and transit routes in break-even analysis. For the purpose of comparison, cost can be annual or monthly. For the sake of convenience, we have chosen annual cost.

a) Annual Cost for Transit Traffic

When telecommunications to a destination are handled by a transit route, the cost can be generally obtained by the mathematical formula shown in the following:

$$y_1 = \frac{2}{3} \times P \times M + \frac{M}{T} \times C_1 + \alpha$$

where y_1 : Annual cost for handling traffic via transit route (to a particular country)

P : Unit charge (charge per minute)

M : Total annual chargeable minutes to the country

T : Annual traffic that can be handled by an additional transit circuit (in minutes)

C_1 : Annual traffic that can be handled by an additional transit circuit (in minutes)

α : Other costs (switching systems, domestic transmission lines, operating costs, etc.)

Of these amounts, $\frac{2}{3} \times P \times M$ is the compensation cost paid to both the transit country and the destination country. $\frac{M}{T} \times C_1$ is the fractional cost of the transit circuit to handle the traffic. T for telephone will be approximately 70,000 minutes/year, and for telex, approximately 36,000 minutes/year, as an additional circuit has to be assigned for each increase of traffic by about 0.8 Erlangs when the loss probability is 0.1 in normal instances (10 transit circuits and more) according to the Erlang B Table.

$$(0.8 \times \frac{60 \times 300}{.15 \times 1.35} \doteqdot 70{,}000,\ 0.8 \times \frac{60 \times 270}{.15 \times 1.35} \doteqdot 64{,}000)$$

b) Annual Cost for Direct Traffic

The cost for the same traffic volume when handled by a direct circuit will be as follows:

$$y_2 = \frac{1}{2} \times P \times M + C_2 \times n + \alpha$$

where y_2 : Annual cost for handling traffic via direct route (to a particular country)

P : Unit charge (charge per minute)

M : Total annual chargeable minutes to the country

n : Number of circuits required for the traffic

C_2 : Annual maintenance cost for a half circuit of the direct route

α : Other costs (switching systems, domestic transmission lines, operating cost, etc.)

The $\frac{1}{2}$ x P x M portion is the compesation cost to be paid to the country on the other end of the circuit. The n x C_2 portion is the circuit maintenance cost.

Installation of a direct circuit will be more economical when $y_1 > y_2$. Note here that the same element α is included for both Y_1 and Y_2.

In this example, for telephone, let us assume that P = 5 (US dollars), T = 70,000 (minutes), $C_1 = C_2 =$ 10,000 (US dollars: payment to INDOSAT and satellite cost are included): Then,

$$Y_1 = \frac{2}{3} \times 5 \times M + \frac{M}{70,000} \times 10,000 = 3.476M + \alpha$$

$$Y_2 = \frac{1}{2} \times 5 \times M + 10,000 \times n = 2.5M + 10,000n + \alpha$$

The following condition is required in order to attain $Y_1 > Y_2$ at that time:

$3.476M > 2.5M + 10,000n$

or,

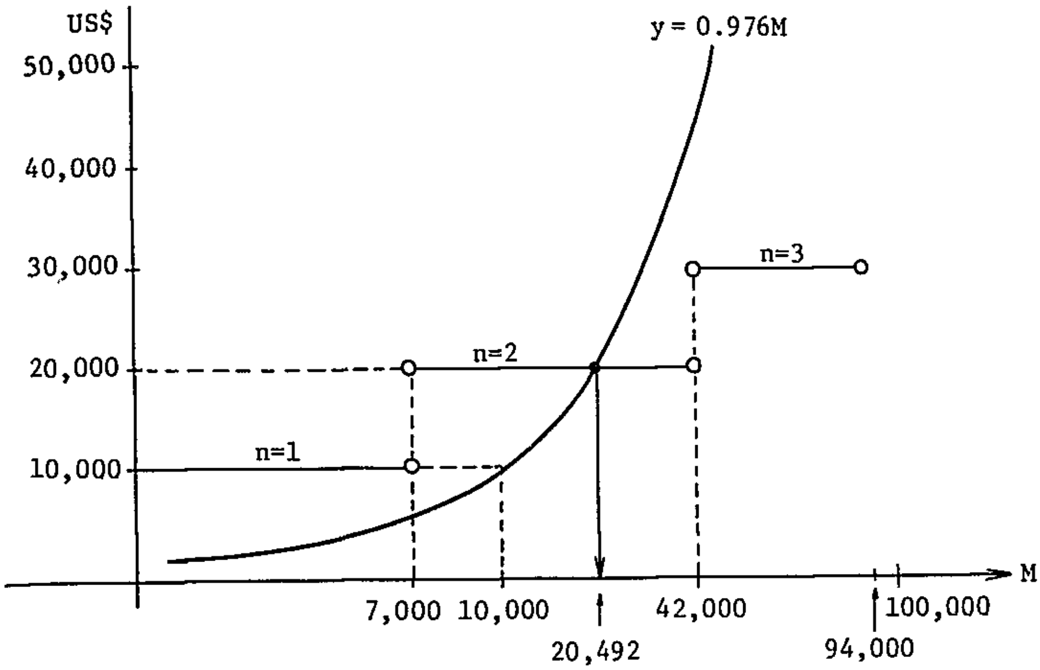
$0.976M > 10,000n$ (provided $n = 1$ $M < 7,000$

$n = 2$ $7,000 < M < 42,000$

$n = 3$ $42,000 < M < 94,000$

$\vdots$ $\vdots$

The foregoing calculations are summarized in the graph shown in the following:



In the graph shown above, the point at which $Y = 0.976\ M$ crosses one of the straight lines running parallel to the x axis is the break-even point. It is clear that n = 2, therefore,

$$0.976\ M = 10,000 \times 2$$

$$M = 20,492$$

Consequently, in this example, a direct circuit is more advantageous when there is traffic in excess of approximately 20,000 minutes/year.

By the way, in the foregoing example, C_1 was set as C_2. However, in some instances, these values differ between transit and direct routes, (namely, $C_1 \neq C_2$). In general, the break-even point is lower with the adjoining countries with which Indonesia is connected by short haul submarine cables. On the other hand, the break-even point is higher with remote countries outside the IS and PS coverages, as telecommunications have to depend on an expensive long haul submarine cable, double hopping of satellites, or a combination of a satellite and a cable.

Moreover, from the standpoint of the corresponding countries, break-even points may differ from those of

P.T. Indosat. (E.g., the cost of the satellite earth station for Kenya may differ from that of Indonesia.)

For the telegraph grade circuits, all the foregoing values differ for P, C_1, and C_2. (Therefore, the values are smaller than 20,000.)

Therefore, the analysis has to be made specifically and individually on a case-by-case basis.

In this master plan, however, it was not feasible to make analysis one by one. Therefore, the following criteria have been tentatively set, and where these criteria are exceeded, installation of new direct circuits has been incorporated assuming that the countries on the other ends of the lines would agree to it.

CRITERIA: Lower limit values for installing direct circuit (shown by annual chargeable minutes)

1. Regions in Indian or Pacific Ocean satellite coverage

Telephone	30,000 minutes/year
Telex	15,000 "

2. Other regions (Central and Latin America, Africa, and part of Europe)

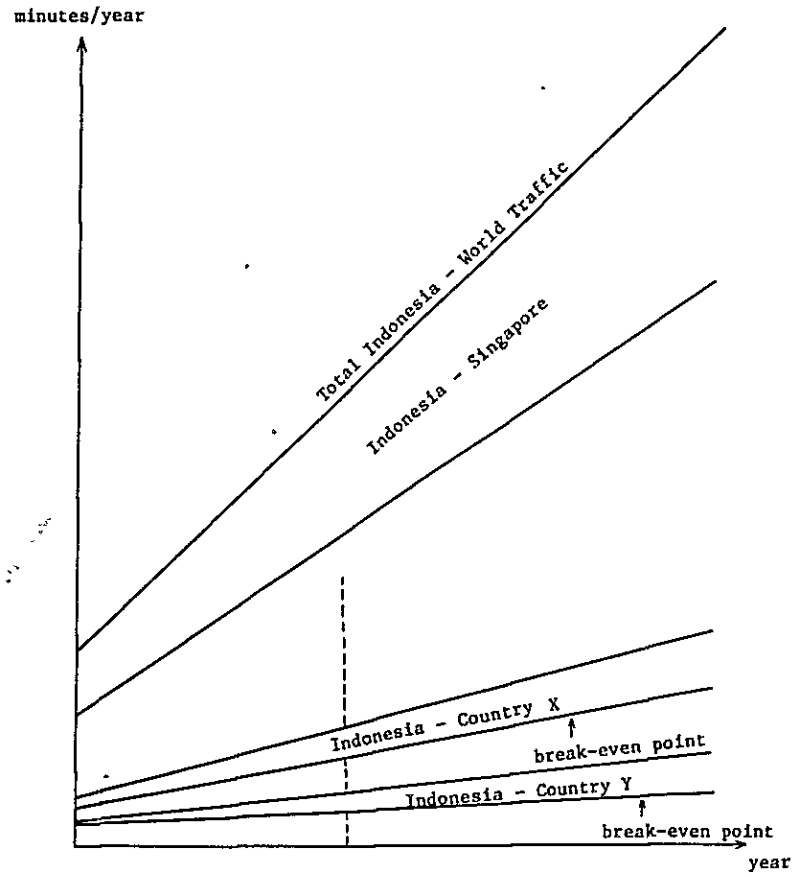
Telephone	70,000 minutes/year
Telex	35,000 "

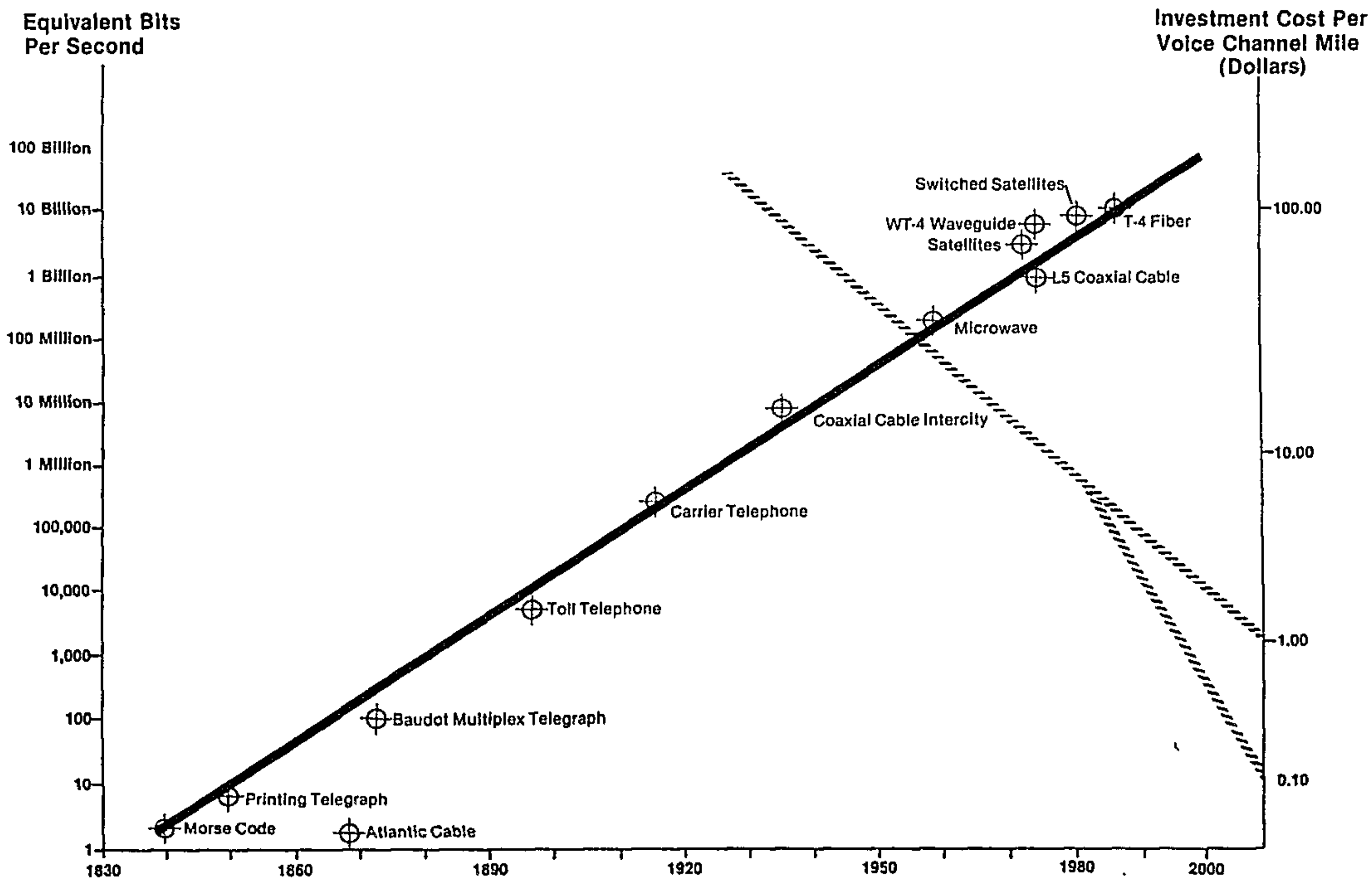
(Note) For your information, KDD normally starts this break-even study when criteria of 20 calls/day (≑ 45,000 minutes/year) for telephone and 15 calls/day (≑ 10,000 minutes/year) for telex are exceeded. However, parallel with advances made in technology, the cost of lines is decreasing (see Figure 4-2), therefore, it is safe to say that the foregoing criteria are reasonable only for the time being.

In any case, it is needless to say that Indonesian traffic to and from each country has its own break-even points, after which it is reasonable for both P.T. Indosat and the correspondent carrier to switch from transit to direct circuits. This concept of break-even points is very much important especially for such countries as Indonesia, where the total traffic level is far below satulation and the number of destination countries is rather limited. In these countries, as the total traffic grows very rapidly, traffics to and from many countries are expected to pass their own break-even points one after another (see the diagram below). In light of securing independence and sovereignty in telecommunications, monitoring and forecasting traffic on a country by country basis is indispensable, too.

Here lies the major reason why forecasting traffic on a country by country basis (excluding countries the traffics to and from which are very small, say less than 1,000 minutes per year) is recommended to be made in spite of enourmous amount of time and energy spent for the task. (See Section 3.3.5)

Necessity for Break-even Analysis





Source: Richard J. Solomon, Massachusetts Institute of Technology

Figure 4.2 The Sequence of Inventions in Telecommunications 1840-2000

4.3 Calculation Method for Determining the Required Number of Circuits

In general, the preparation on the following items must be made before starting the calculation work.

a) Traffic forecst on a country by country basis (for international circuits requirement) and a WITEL by WITEL basis (for domestic circuits requirement)

b) Standards on service quality (e.g., response time, connection rate, etc. See Section 7.2.2)

c) Domestic routing plan (See Sections 5.2.1 & 5.2.2)

d) Study on the division of revenue (i.e., break-even analysis)

e) Study on diversity in routing (i.e., all the utilizable broad-band routes (cable, micro and/or satellite) to countries with which direct circuits are or will be set up. (See Appendix 4.3-1 & 4.3-2.)

Then, the quantity of circuits required is calculated based on the forecasted traffic volume in the busy hour on busiest working day of the planned year according to the following steps (In case of domestic circuit, some modification is necessary, though):

(1) Calculation of traffic volume to be carried by each circuit group

Suppose the demand forecast on a country by country basis is already given. It is necessary then to convert the traffic demand for each country to the traffic demand for each circuit group. (In this master plan, we call this "traffic by circuit". As to the difference between the concept of "traffic by country" and "traffic by circuit", see Appendix 3.2.6-3).

The traffic demand handled by a certain group of direct circuits is calculated by adding the portion of the traffic demand for that direct circuit's country which is handled by that circuit and the traffic demand beyond that country which is handled via that circuit. (In addition, it is necessary to take into consideration the difference of the busy hours, when you bundle the different streams of traffic. This problem can be solved by setting an appropriate concentration rate. As to the concentration rate, see the next paragraph.)

(Example)

Traffic by country (minutes)		Distribution Ratio* (%)		Traffic by Circuit (minutes)	
Singapore	10,000	SIN	90	SIN	9,000
		J	5		+) 250
		USA	5		9,250
Japan	5,000	J	95	J	4,750
		SIN	5		500
					+) 300
					5,550
USA	3,000	USA	90	USA	2,700
		J	10		+) 500
					3,200

* ratio of the traffic which is handled via a particular route to the total traffic to and from a certain country.

(2) Estimation of the number of working days per year and the concentration rate

In the next step, in order to obtain the traffic volume per average working day (then for the busiest working day), the number of working days per year should be estimated from the traffic data and other information (holidays) for each direct circuit's country. In general, however, typical figure is uniformly used for all destinations of direct circuits for each service. (e.g., 270 days per year is used for all the telex circuits.)

In addition, concentration ratio should be estimated for each direct circuit group from the historical traffic data ("traffic profile").

(3) Calculation of traffic volume for the busiest working day of the planned year

Then, the traffic volume for a busiest working day of the planned year should be obtained. Different assumptions can be used in this process. An example is to assume that traffic grows month by month, thus, that the busiest day is the day at the year end. Another example is to assume that the busiest working day has constant ratio (so called "seasonal factor") to average working day.

If we follow the former assumption, traffic volume for the busiest working day (or the day at year end) is calculated by the following formula.

$$T_b = \frac{T_t + T_{t+1}}{2} \times \frac{1}{D_w}$$

T_b : traffic volume for the day at year end in calls
T_t : annual traffic for the planned year
T_{t+1} : annual traffic for the next year
D_w : working days per year

If we use the latter assumption, traffic volume at the busiest day would be:

$$T_b = T_t \times \frac{1}{D_w} \times S$$

S : seasonal factor (e.g., 1.2)

(4) Determination of the number of circuits required

Naturally, each circuit group is required to have enough capacity to carry a given traffic intensity. In a usual case, the traffic intensity in the so called busy hour of the busiest working day of the planned year is set as a goal for circuit capacity.

Given that the traffic volume in minutes in busy hour is already forecasted, for telex and telephone services, the traffic intensity in the busy hour (generally expressed in Erlangs) can be calculated by the following formula:

$$E = T_b \times \frac{P_c}{100} \times h \times \frac{1}{60}$$

E : traffic volume in the busy hour in Erlangs

P_c : concentration rate of the busy hour in %

T_b : Traffic volume for the busiest day in calls (given in (3))

h : average holding time per call in minutes, which consists of the average chargeable time (minutes) and average handling time (minutes) per effective call. And the latter is obtained as follows:

$$\text{average handling time (per effective call)} = \frac{\text{total minutes spent for handling (including those for ineffective calls)}}{\text{number of effective calls}}$$

The number of circuits required to carry a certain traffic stream can be obtained mathematically, if the loss probability in addition to the Erland value of the traffic is given. For telex the Erland Table of CCITT Recommendation F64 can be used. As to telephone the CCITT Recommendation E510 can be applied for manually operated circuits, and the CCITT Recommendation E520 can be applied for semi-automatic and fully-automatic circuits.

The following formula can also be used to calculate the required number of circuits.

$$P = \frac{\frac{E^n}{n!}}{1 + \frac{E}{1!} + \frac{E^2}{2!} + \ldots + \frac{E^n}{n!}}$$

P : loss probability

E : traffic offered in erlangs

n : number of circuits

(Note) For actual calculation, however, at least the programmable calculator is needed. Sample program in BASIC language is shown in Appendix 4.3-5.

Based on the above steps, sample working format is shown in Appendix 4.3-3 (for Telephone) and Appendix 4.3-4 (for Telex).

(5) Comparison of the Calculated Erlang values with Measured Erlang Values

In general, the above method is used for a long or medium term plan. On the other hand, an actual circuit installation should incorporate measurement of erlang value directly through erlang counter, especially from the point of view of determining circuit requirement for short term basis.

Accordingly, comparison and adjustment between the calculated erlang values and those based on the direct measurement should be made in an actual circuit planning.

4.4 International Circuits for Telephone

4.4.1 Tabulation of Traffic Forecast Values Broken Down by Circuit and Gateway Office

The master plan has used a following criteria when converting traffic forecast values broken down by country obtained in Paragraph 3.3.5 (Appendix 4.4.1-3) to circuit-by-circuit traffics.

CRITERIA:

1. Indonesia is assumed to install direct circuit(s) when traffic exceeding the break-even point shown in Section 4.2 is generated with a destination country. Upon completion of the circuits, 100% of the traffic with that country will shift to the new circuit(s).
2. The proportion of traffic using transit routes to total traffic to and from a certain country should preferably be 5% or less (if possible, 0%). Therefore, when the proportion in the past exceed 5%, 5% is utilized as a maximum proportion for transit routes. Where actual proportions are less than 5%, these actual proportions are used as they are.
3. For destinations without direct circuits and whose traffic has not reached a break-even point, the traffic is to be distributed between the first and second route in accordance with the previous proportions.

Appendix 3.2.1-3 shows performance records and Appendix 4.4.1-5 gives planned distribution ratio based on the foregoing CRITERIA.

Appendix 4.4.1-6 tabulates resultant traffic by circuit. Traffic of the other countries not included in the traffic forecasts broken down by country has been distributed as shown in Appendix 4.4.1-4 based on previous traffic proportions broken down by circuit and has been included in Appendix 4.4.1-6.

Appendix 4.4.1-7 shows separate traffics by gateway office, i.e., Medan and Jakarta. This distribution should preferably be performed based on previous proportions of each country by gateway. However, since past data in this respect was not available, the assumptions regarding the proportion of Sumatra in entire traffic have been used in forecasting traffic by circuit as well.

4.4.2 Calculation of Number of Required Circuits

The work to calculate the number of required circuits based on the foregoing traffic forecast values broken down by destination and by gateway office can be divided into 2 stages. In the first step, busy hour erlang values are calculated from traffic values. In the second step, the number of required circuits is read from the Erlang B Table in accordance with E520 of the CCITT Recommendations.

Circuit installation from Medan will be limited to the 8 Southeast Asian countries and to European regions whose traffic has reached the above-mentioned break-even point.

In all other countries, Jakarta Gateway will handle the traffic generated from Sumatra.

Based on the total annual chargeable minutes by circuit, busy hour erlang values have been derived from the following mathematical formula

$$\text{BHE} = \frac{\text{Concentration ratio} \times 1.35}{60 \times 300} \times \frac{\text{Total minutes}_t + \text{Total minutes}_{t+1}}{2}$$

assuming the number of ordinary days to be 300 and the holding time/chargeable time ratio to be 1.35. The concentration ratios adopted were the average of those measured on 3 days from December 15 to 17 in 1981 on the existing circuits. The following assumption has been made for new destinations taking time difference into consideration.

ASSUMPTION: Concentration ratio (where measured values are not available)

Time difference	0 - 2 hrs :	0.10
"	6 - 7 hrs :	0.15
"	Others :	0.13

KDD also uses similar values. The time difference between Jakarta and Tokyo is small, therefore the foregoing assumption is considered reasonable. Appendix 4.4.2-1 shows concentration ratios to be applied to individual destinations.

These concentration ratios and busy hour erlang values calculated on the foregoing mathematical formulas are shown in the upper case of Appendix 4.4.1-7.

Appendix 4.4.2-2 shows the required number of circuits calculated from these erlang values by using a loss probability of 1% in accordance with the CCITT Recommendations E520.

The summary of the result is shown below:

Table 4.4.2 Number of International Circuits for Telephone between Indonesia and the World

Year	Jakarta Gateway	Medan Gateway	Indonesia Total
1983	714	-	714
1984	824 .	75	899
1985	1,027	143	1,170
1986	1,236	172	1,408
1987	1,491	233	1,724
1988	1,775	295	2,070
1989	2,094	357	2,451
1990	2,445	421	2,866
1994	3,848	734	4,582
1999	5,844	1,254	7,098
2000	6,239	1,367	7,606

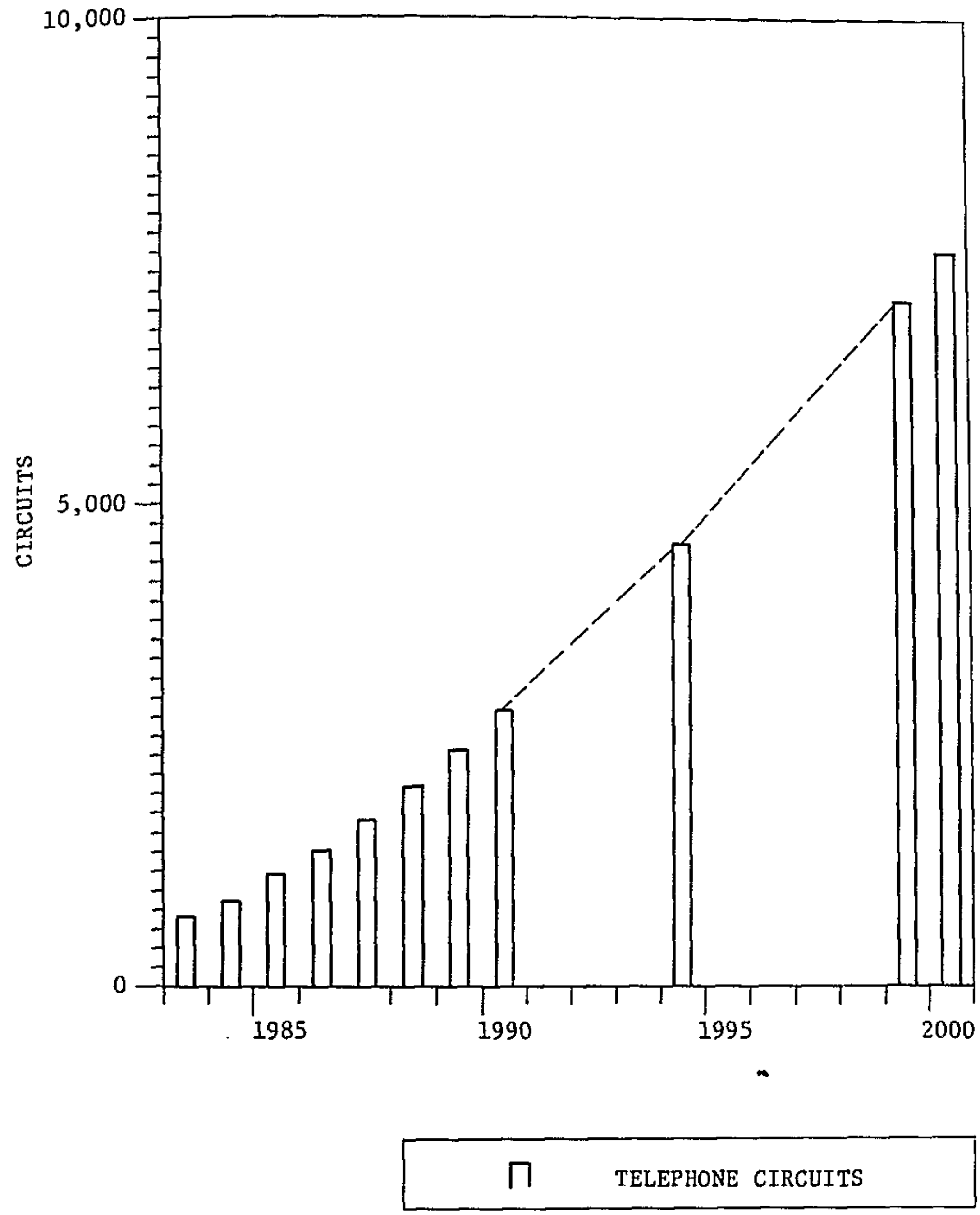


Figure 4.4.2.1 International Circuits for Telephone

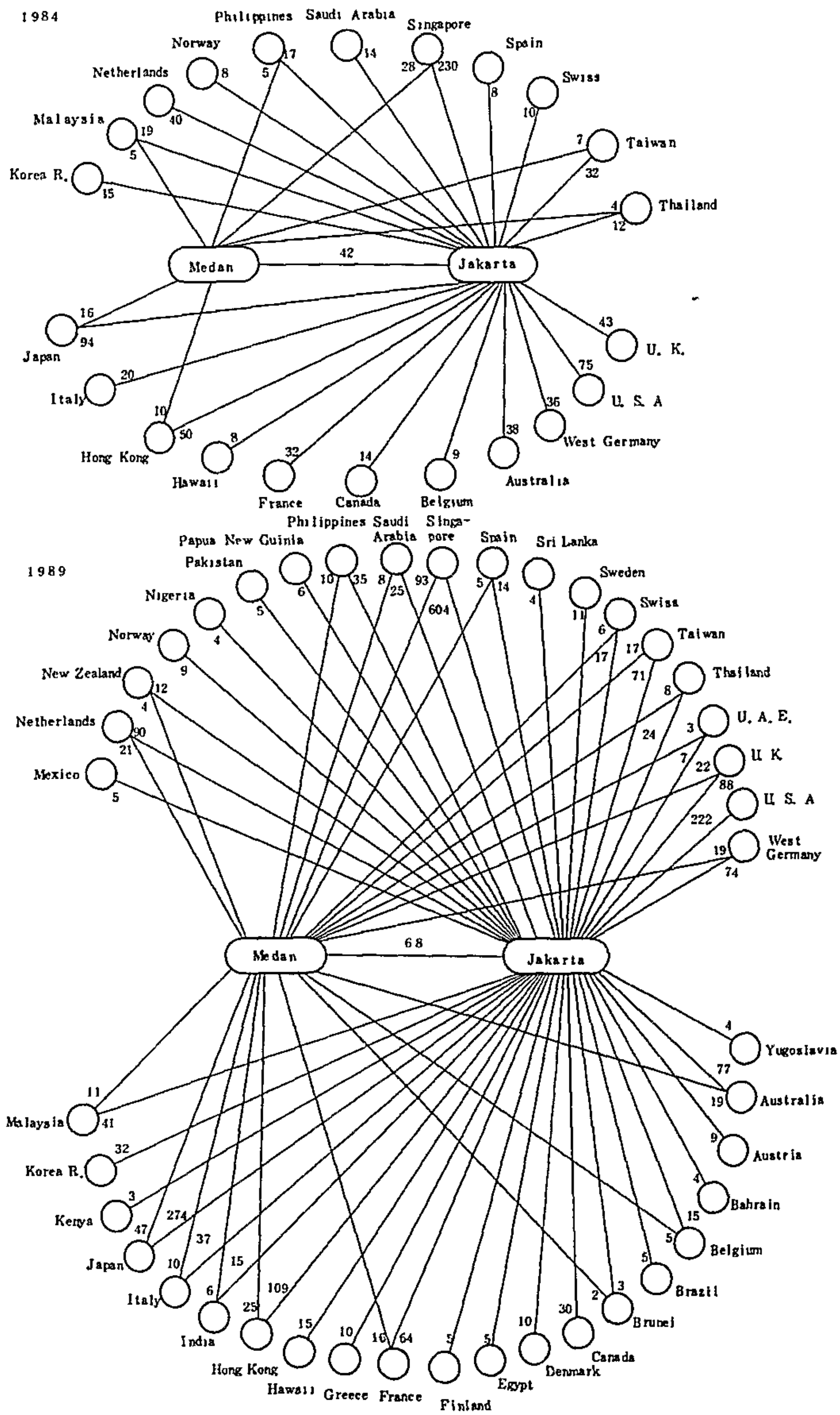


Figure 4.4.2.2 Increase in Telephone Direct Circuit Destinations

4.5 International Circuits for Telex

4.5.1 Forecast of Traffic by Destination and Gateway Office

The method to obtain traffic forecast values for telex broken down by circuit is basically the same as that for telephone.

Appendix 4.5.1-5 shows previous records and planned ratios of traffic distribution.

Based on these distribution ratios, traffic broken down by circuit is tabulated in Appendix 4.5.1-6. As is the case with telephone, traffic for other countries that cannot be tabulated in traffic forecasts by country has been distributed as shown in Appendix 4.5.1-5 based on the previous proportions for the traffic broken down by destinations. This traffic is included in Appendix 4.5.1-6.

Appendix 4.5.1-7 shows the circuit-by-circuit traffics distributed separately for the Medan and Jakarta offices. As is the case with the telephone, the assumption with respect to proportions between Sumatra and other regions in total traffic has been used uniformly.

4.5.2 Calculation of Required Number of Circuits

When calculating busy hour erlang values based on total annual chargeable minutes by circuit, the following mathematical formula is used:

$$BHE = \frac{\text{Concentration ratio} \times 1.35}{60 \times 270} \times \frac{\text{Total minutes}_t + \text{Total minutes}_{t+1}}{2}$$

Due to a lack of measurement data, the concentration ratios have been set as shown in the following considering the time difference with each destination:

ASSUMPTION : Telex concentration ratio

Asia, Australia, and New Zealand:	.15
North and Latin America, Europe, and Africa:	.20

Appendix 4.5.2-1 shows the concentration ratios to be applied by destination. Busy hour erlang values calculated by using these concentration ratios in the foregoing mathematical formula are shown in the upper case of Appendix 4.5.1-7.

Appendix 4.5.2-2 shows the required number of circuits calculated by applying a loss probability of 2% based on the CCITT Recommendations. The summary is as follows:

Table 4.5.2 Number of International Circuits for Telex between Indonesia and the World

Year	Jakarta Gateway	Medan Gateway	Indonesia Total
1983	522	-	522
1984	565	40	605
1985	694	88	782
1986	768	103	871
1987	841	126	967
1988	933	152	1,085
1989	1,012	174	1,186
1990	1,080	189	1,269
1994	1,292	258	1,550
1999	1,445	333	1,778
2000	1,471	350	1,821

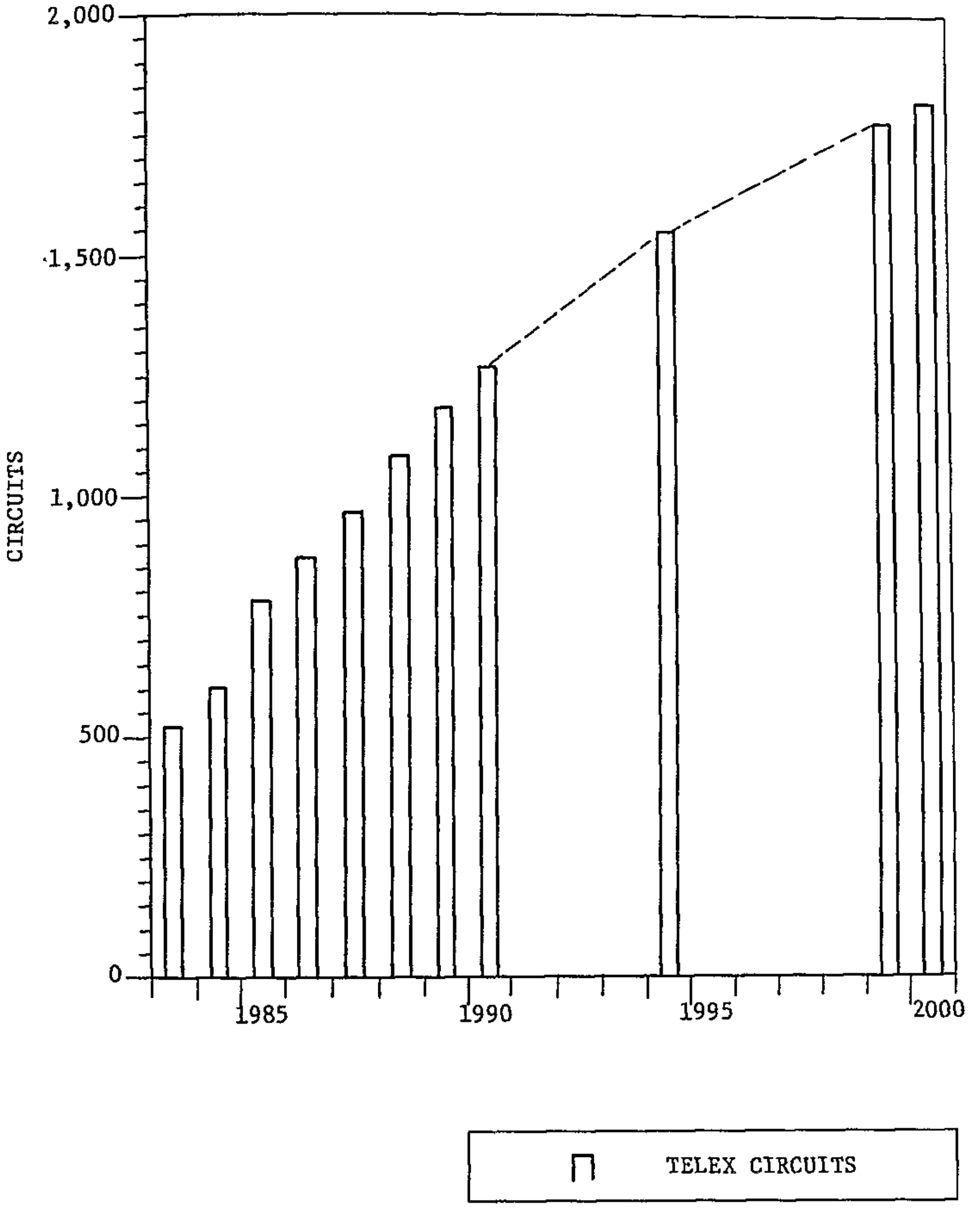


Figure 4.5.2.1 International Circuits for Telex

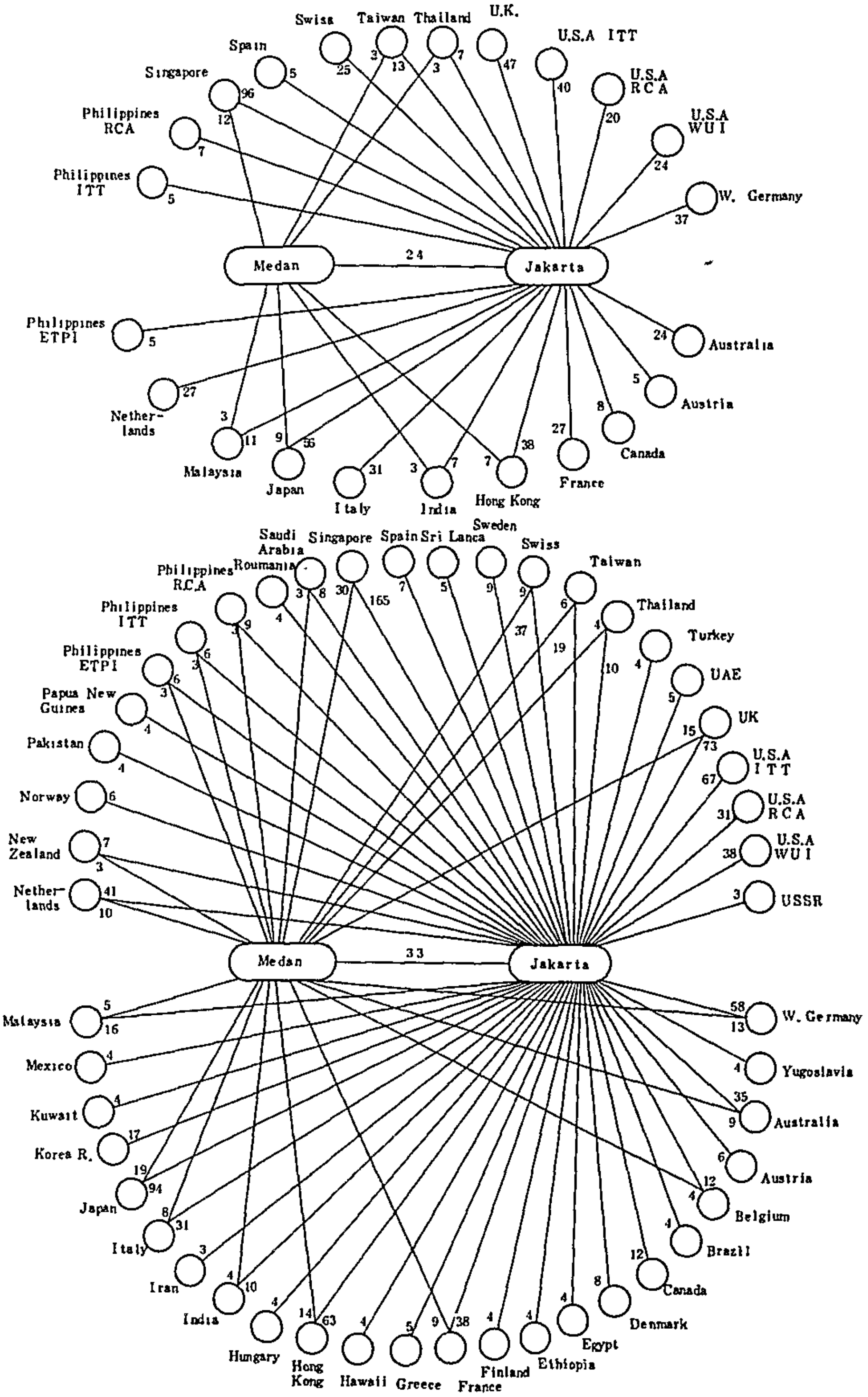


Figure 4.5.2.2 Increase in Telex Direct Circuit Destinations

4.6 International Circuits for Other Services

4.6.1 Circuit Requirement for Packet Switching Service

The required number of circuits has been calculated based upon the estimated total traffic demand for the four major applications shown in Section 3.9.3. The calculation procedure is shown in Appendix 4.6.1-1. The resultant number of circuits required (9.6 Kbps per circuit) is as follows.

Year	85	86	87	88	89	90	94	2000
Number of ccts (9.6Kbps)	1	2	3	4	6	8	19	70

At the inaugulation time, the service is supposed to be offered with four countries, Japan, the USA, Singapore and United Kingdom via six direct circuits (three circuits with the IRC's in the USA) from the point of view of expected traffic distribution. Within several years, direct circuits with France, Australia and West Germany are supposed to be installed and many other countries are served through transiting. (See Figures 4.6.1.1 and 4.6.1.2.)

4.6.2 Circuit Requirement for Telegram and Leased Circuits Services

In this master plan, a direct circuit is assumed to be inaugulated whenever a VFT (or TDM) is installed to initiate direct telex circuit(s) (See Appendix 4.7.1-3).

Circuit requirement for leased circuits is given in the chapter for demand forecast (See Section 3.6 and Appendices 4.7.1-2 and 4.7.2-2).

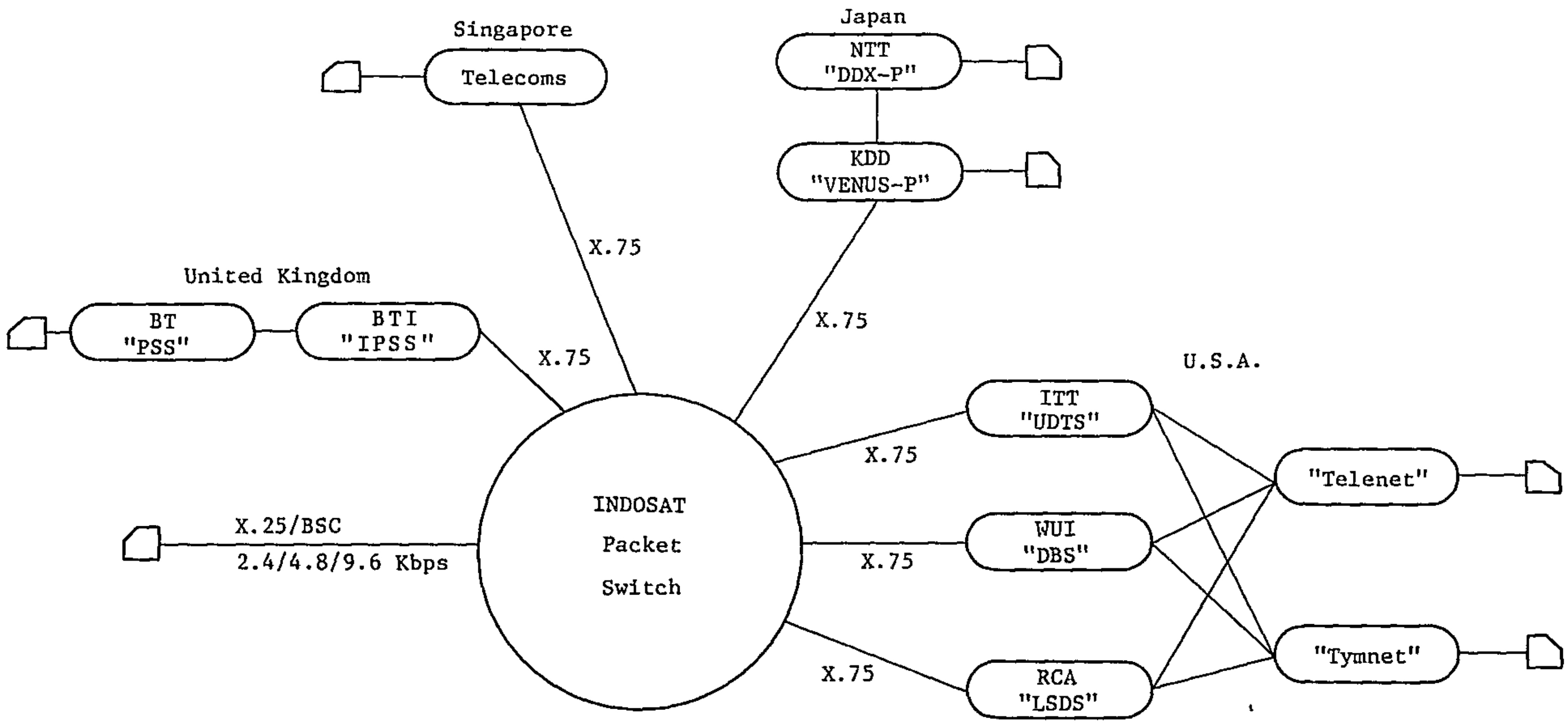


Fig. 4.6.1.1 International Packet Switching Network - 1985

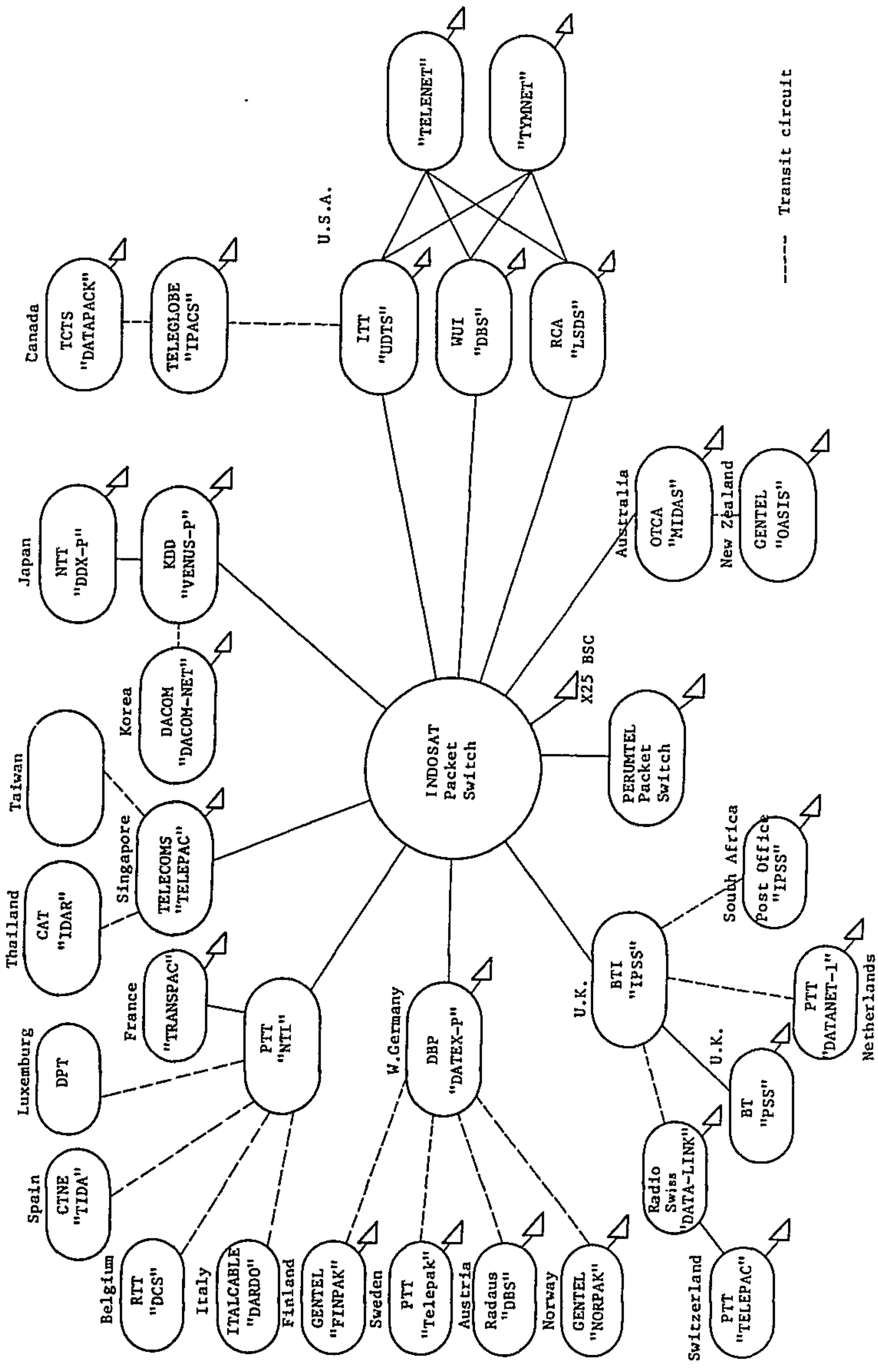


Figure 4.6.1.2 International Data Network - 1989

4.7 Tabulation of Number of International Circuits by Transmission Route

4.7.1 Tabulation of Numbers of Telegraph-Grade and Voice-Grade Circuits

After classifying circuit requirement calculated earlier for telephone, telex, telegram, leased circuits and new services into telegraph-grade and voice-grade, total telegraph-grade circuits have first been tabulated by country, year, service, and gateway as shown in Appendix 4.7.1-3.

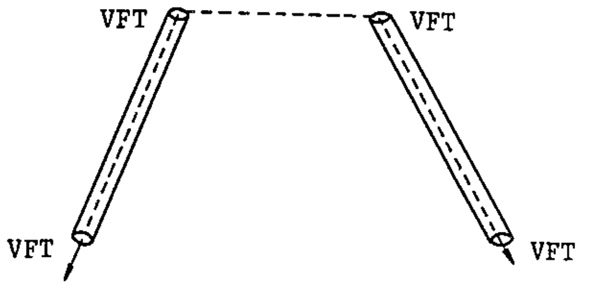
As a next step, voice-grade circuits have been tabulated in Appendix 4.7.2-3 by country, year, service, and gateway. In this step, VFT or TDM are employed for destinations with large numbers of telegraphic circuits (See Appendix 4.7.2-1).

The flowchart of this tabulation process is shown in Appendix 4.7.1-1.

The following judgments have been made in setting destinations for telegraph-grade circuits.

CRITERION: A direct VFT circuit is to be opened, when there is demand for more than 3 circuits for the telegraph type including one for telegram service, even if there is no direct circuit requirement with that country for telephone.

The foregoing steps may not be necessarily desirable from the standpoint of economy. When the requirement for circuits is low, it may be reasonable, in some instances, to find a third country that has empty VFT channels with Indonesia and also with the desired destination of connection and then to lease a circuit and part of the VFT from her.



The master plan has, however, been made based on the assumption that P.T. INDOSAT will install direct channels whenever possible in line with Indonesia's determination to become one of the communication centers in Southeast Asia.

4.7.2 Distribution of Voice-Grade Circuits by Transmission Route

The distribution of voice-grade circuit requirements including VFT channels by transmission route has been made, in principle, based on the following criteria, except when only one type of transmission route is possible:

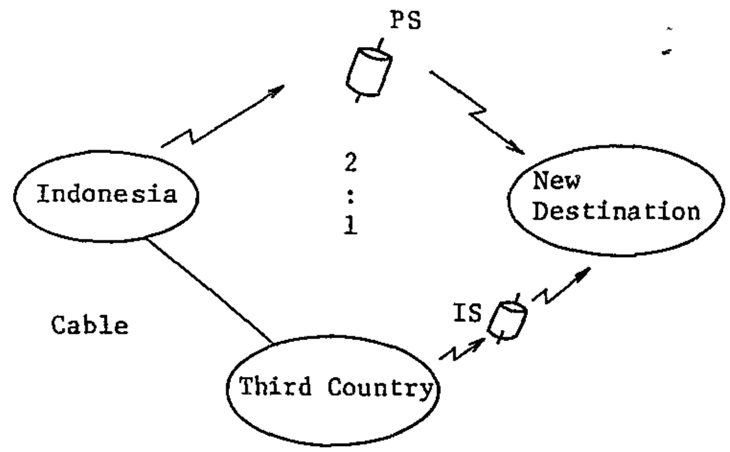
CRITERIA:

1. Where both the Indian and Pacific Ocean satellites can be used, utilization will be made as designated by INTELSAT.

Japan	PS	Singapore	IS
Hong Kong	PS	Taiwan	PS
Rep. of Korea	PS	Thailand	PS
Malaysia	PS	Australia	PS
Philippines	IS		

2. Where communications via several alternative cable routes are possible, those routes that utilize domestic routes of third countries are excluded in principle. (New Zeland will be connected via the I-A cable only, therefore, that route is not excluded)

3. When installing a transmission route serially combining a submarine cable and a satellite with a destination with which communications with one satellite are possible, the ratio between the two has been set at 2:1.



(Example)

USA	PS (2/3), IS - TAT Cable (1/3)
New Zealand	PS (2/3), IA Cable - ANZCAN Cable (1/3)

4. Where either a submarine cable or a satellite can be used, the proportion between the two shall be decided as shown below, using direct distances between Jakarta and the capitals of the correspondence countries as a criterion.
The ratio is applied to totals of circuits accommodated in either Jakarta or Medan Offices.

		Satellite/Cable		
Neighboring countries	(4000 km or less)	30	:	70
"Break-even" countries	(4000 - 10,000km)	50	:	50
Remote countries	(10,000km and over)	90	:	10

5. Of traffic between Jakarta and Europe, the portion of traffic distributed to Indian Ocean cable should preferably be carried via the domestic network. However, for the time being, the traffic will be routed through the IS Cable (then through MS Cable and MC Cable).

Appendix 4.7.2-4 shows planned usage ratio by route base on the foregoing criteria. Appendix 4.7.2-3 mentioned earlier shows the result of distribution by transmission route in accordance with these usage ratios.

In the actual work to distribute traffic, interim measures should be incorporated before the goal values are attained. And for leased and VFT circuits, an equal distribution (50:50) has been adopted between satellites and submarine cables from the standpoint of reliability, customer wishes, etc. even though the goal values might be difficult to realized in short time.

Table 4.7.2 shows the number of Indonesia's total international voice grade circuits requirement by transmission route. (This table includes transit requirement for Medan-Singapore-Jakarta cable. For transit requirement, see Appendix 4.7.2-5.)

Table 4.7.2 Circuit Requirement by Transmission Route

Transmission Route				84	85	86	87	88	89	90	94	2000
Satellite	Jakarta	Pacific Satellite		235	294	335	418	484	564	644	991	1,591
		Indian Satellite		333	407	470	567	672	778	894	1,393	2,238
Cable	Jakarta	Jakarta-Singapore	Jakarta -World	309	412	457	603	715	842	992	1,539	2,467
			Medan * -Australia, N Z	-	-	-	19	21	25	29	42	71
			Total	309	412	457	622	736	867	1,021	1,581	2,538
		Jakarta-Perth	Jakarta -Australia, N Z	-	-	-	6	18	30	41	89	142
			Medan -Australia, N Z	-	-	-	19	21	25	29	42	71
			Total	-	-	-	25	39	55	70	131	213
	Medan	Medan-Singapore	Medan -Asia	75	91	111	144	179	215	256	453	882
			Jakarta * -Europe	-	40	50	54	62	71	81	119	182
			Total	75	131	161	198	241	286	337	572	1,064
		Medan-Penang		7	11	13	14	17	19	21	30	48
		Medan-Colombo	Medan -Europe	-	55	62	78	103	123	141	217	371
			Jakarta -Europe	-	40	50	54	62	71	81	119	182
			Total	-	95	112	132	165	194	222	336	553

* transit requirement

4.8 Domestic Circuits

4.8.1 Tie Lines Between Gateway Offices

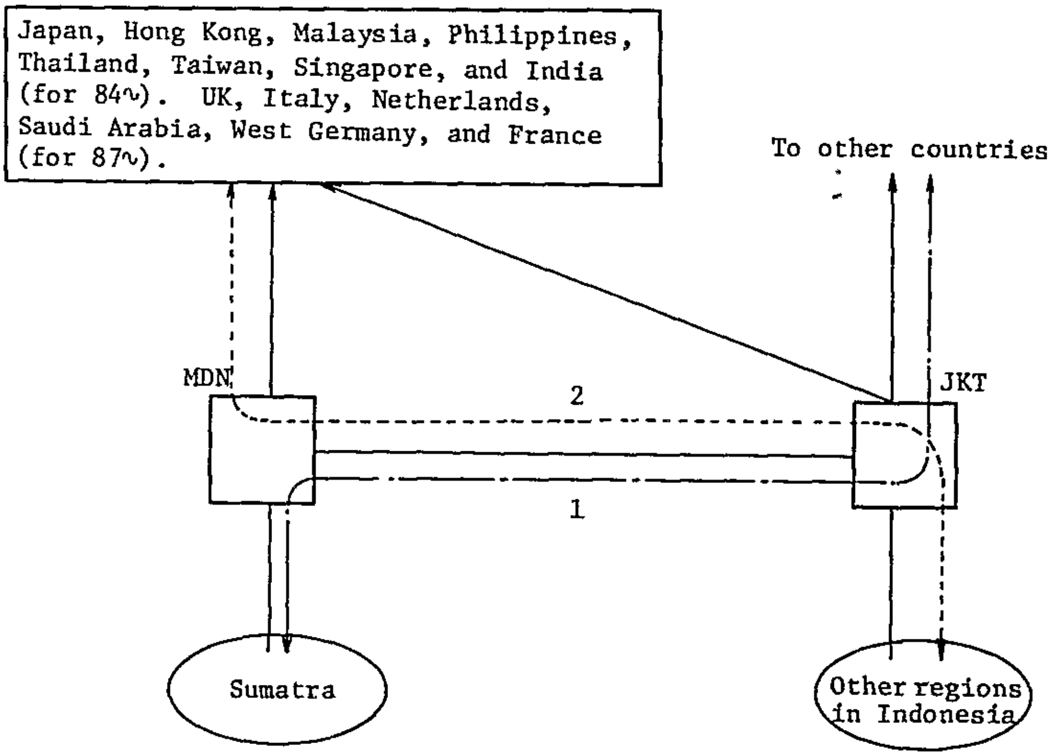
In principle, from the basic guideline described in Section 4.1 above, tie lines between the gateway offices in Medan and Jakarta should be used only to divert traffic generated from Sumatra with respect to those destinations that are not accommodated in the Medan gateway office. However, as countermeasures for emergencies and as measures for traffic overflow from Jakarta to Medan, which originates in regions other than Sumatra and lands in Asian countries, the master plan has adopted the following criteria.

CRITERIA: Traffic between Jakarta and Medan Gateway Offices

The traffic between these two gateway offices is the sum of the traffic generated from Sumatra with respect to the destinations that are not accommodated in the Medan Gateway Office, and the traffic overflowing from Jakarta, which is assumed to be 10% of the traffic generated from Sumatra with respect to the desitnations that are accomodated in the Medan Gateway Office. (See the diaqram below)

Busy hour erlang values and the number of circuits calculated for telephone and telex traffic based on Appendices 4.8.1-2 and 4.8.1-3 in accordance with the foregoing criteria are shown in the following.

Busy Hour Erlang Traffic Broken Down by Gateway Office



1 Originating in Sumatra and terminating in other countries

Terminating in Sumatra and originating in other countries

2 Overflow of traffic (via Medan Gateway Office) originating in other regions in Indonesia and terminating in the countries shown in the diagram above enclosed in □

Traffic originating in the countries enclosed in □ and terminating in other regions in Indonesia via the Medan Gateway Office

Emergency countermeasures

} *

* ② is assumed here to be about 10% of traffic generated from Sumatra with respect to the countries enclosed in □.

Table 4.8.1 Number of Tie Lines between Jakarta and Medan Gateways

Year	Telephone #circuit	Telex		Total voice circuit
		#circuit	#TDM	
1984	42	24	1	43
1985	37	19	1	38
1986	47	23	1	48
1987	44	24	1	45
1988	54	28	1	55
1989	68	33	1	69
1990	84	38	1	85
1994	160	50	2	161
2000	330	68	2	331

4.8.2 Tie Lines Between Gateway and Domestic Networks

(1) Telephone Tie Lines

Fig. 4.8.2.1 shows the types of calls on tie lines with the domestic network and their traffic direction. Because of call-back connection calls, the direction of tie line traffic does not coincide with that of international circuit traffic, and the volume of outgoing traffic on tie lines with domestic network is heavier than that of incoming traffic. The ratio of outgoing and incoming traffic will approach 50/50 through increases in the ISD ratio and CLR (combined line and recording) operation ratio. It should be noted that the information call and charge notice call traffic increases in proportion to the total traffic.

(a) Development of the Number of Telephone Tie Lines

Tie lines are calculated by breaking them down into outgoing and incoming on the premise that they will be used single way. Tables 4.8.2.1 and 4.8.2.2 show the requi number of tie lines for Jakarta and Medan Gateways respectively.

(b) Calculation Method

Busy hour erlang was calculated based on the number of calls and mean holding time for each planned year by the following call types. Busy hour erlang was tabulated into outgoing and incoming to obtain the number of circuits.

- International incoming calls
- ISD calls
- CLR calls
- Call-back calls
- Booking calls
- Information calls
- Charge notice calls

① Busy Hour Erlang Calculation Method

$$BHE = \frac{C_1 \times H}{C_2} \times \frac{Nt + Nt{+}1}{2} \times \alpha \times \frac{1}{60}$$

where BHE : Busy Hour Erlang (erl)
(See Appendix 4.8.2-3)

C_1 : Concentration Ratio (0.1)

C_2 : Number of working days per year (300)

H : Mean Holding Time
(See Appendix 4.8.2-4)

Nt : Number of calls in the planned year including incomplete calls
(See Appendix 4.8.2-5)

Nt+1 : Number of calls in a year after the planned year including incomplete calls
(See Appendix 4.8.2-5)

α : Allowance in Forecast (1.2)

② Method for Calculating Number of Circuits

The number of circuits was calculated by the Erlang B formula based on Loss Probability = 1/100 when busy hour erlang was 100 erl or less.
The number of circuits was calculated based on

$$\text{number of circuits} = \frac{\text{Busy hour erlang (erl)}}{\eta}$$

$$\eta = 0.75$$

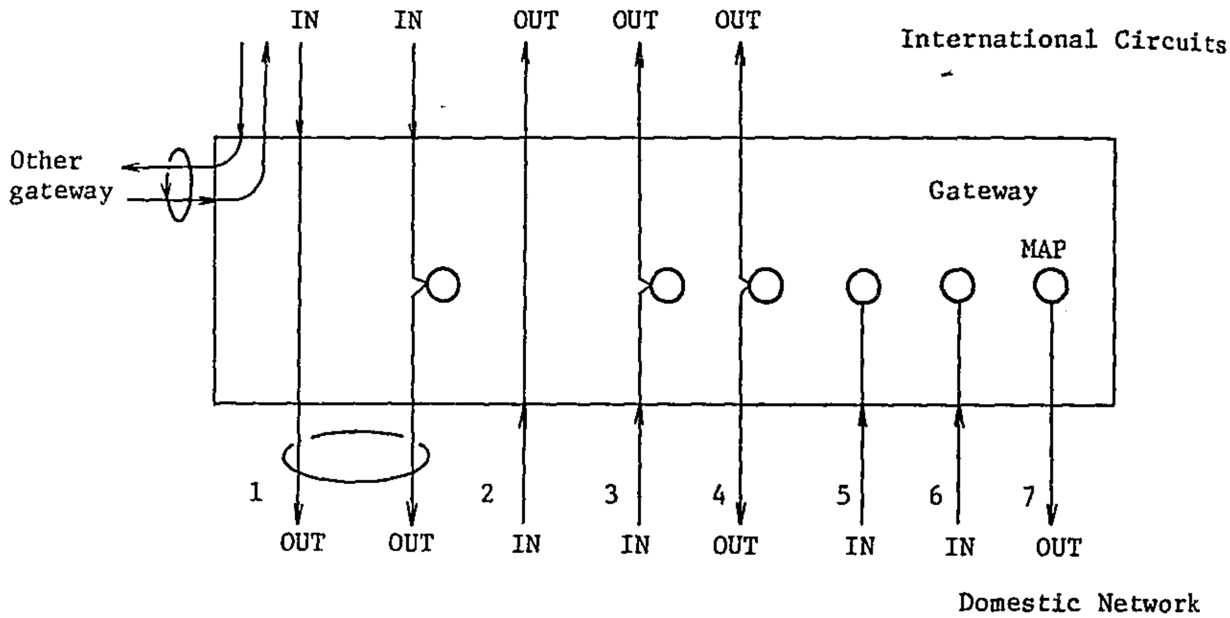
when busy hour erlang was more than 100 erl.

③ Other Factors Used in Calculations

ISD Ratio See Table 3.3.2.
CLR Ratio See Appendix 4.8.2-6
Ratio of cancellation of calls booked: 0.5
Ratio of information calls to complete O.G. calls: 0.01

Ratio of charge notice calls
to complete O.G. calls: 0.15

Completion Ratio See Appendix 4.8.2-5 (3)



1 International Incoming Call
2 ISD Call
3 CLR Call
4 Call Back Connection Call
5 Booking Call
6 Information Call
7 Charge Notice Call
8 Inter Gateway Call

Fig. 4.8.2.1 Telephone Traffic Flow

Table 4.8.2.1 Number of Tie Lines for Telephone between Jakarta Gateway and Domestic Network

(Circuits)

Year	Outgoing Circuits	Incoming Circuits	Total
1984	650	280	930
1985	780	360	1,140
1986	920	470	1,390
1987	1,080	600	1,680
1988	1,270	750	2,020
1989	1,490	920	2,410
1990	1,700	1,100	2,800
1994	2,600	1,800	4,400
1999	3,800	3,000	6,800
2000	4,000	3,200	7,200

Table 4.8.2.2 Number of Tie Lines for Telephone between Medan Gateway and Domestic Network

(Circuits)

Year	Outgoing Circuits	Incoming Circuits	Total
1984	90	25	115
1985	110	40	150
1986	140	55	195
1987	160	75	235
1988	200	100	300
1989	260	140	400
1990	310	180	490
1994	540	360	900
1999	950	710	1,660
2000	1,020	770	1,790

(2) Tie Lines for Telex Network

Since the dominant part of telex service is in fully automatic operation, the planning of domestic circuits is much simpler than that of telephone. The number of tie lines between gateways and the domestic network is calculated from the traffic growth estimation in Busy Hour Erlang values (BHE) by each related WITEL shown in Appendix 4.8.2-8.

Based on the network configuration shown in Fig. 5.2.2.1, domestic trunks are grouped by and interconnected with each domestic tandem exchange. The BHE estimated for each group of tandem exchange and the required number of tie lines are shown in Appendix 4.8.2-9. To calculate tie lines from the BHE, the loss probability 1/100 is applied. In order to obtain the BHE at the end of the years 1990, 1994, 2000, a six month increment is calculated from the yearly increase by extrapolation and is then added to each year value, i.e.,

$$BHE\ (End\ of\ Year) = R \times BHE\ (Middle\ of\ Year)$$

$$R = 1 + (BHE(y) - BHE(Y-y))/\ BHE(Y) \times 1/Y \times 1/2$$

R : Increase ratio in six months

Y : Year concerned

y : Year interval

Tables 4.8.2.3 and 4.8.2.4 shows the required number of tie lines for Jakarta and Medan Gateways respectively.

Table 4.8.2.3 Number of Tie Lines for Telex between Jakarta Gateway and Domestic Network

Year	Bothway Circuits by Tandem Exchange			
	Jakarta	Surabaya	U. Pandan	Total
1984	384	37	8	429
1985	442	41	9	492
1986	501	46	10	557
1987	565	51	11	627
1988	629	56	11	696
1989	693	61	12	766
1990	758	67	13	838
1994	941	79	16	1,036
2000	1,098	90	18	1,206

Table 4.8.2.4 Number of Tie Lines for Telex between Medan Gateway and Domestic Network

Year	Bothway Circuits
1984	41
1985	52
1986	65
1987	80
1988	96
1989	115
1990	140
1994	195
2000	277

CHAPTER III

5

5. Facilities

5.1 General Overview of New Technology

5.1.1 Trends in Switching Technology

(1) Transition of Switching Technology

Through the development of semi-conductor technology, especially the increase in integration, innovation in the automatic switching scheme has become possible.

One of the main trends is the transition in switching elements i.e., from electro-mechanical switches such as step-by-step strowger mechanisms, cross-points or reed relays to purely electronic devices. Associated with this in the field of circuit switching, which is applied in telephone, telex and data, the switching scheme is being modernized from space division into time division. Furthermore in the field of message switching, computer technology has given birth to a new sophisticated technology such as packet switching.

This transition gives the possibility of high quality and reliability, less maintenance, space saving, cost reduction and, in all aspects, better service to customers.

(2) Hardware Technology

Remarkable progress is being made in the higher integration of semi-conductor elements and electromagnetic devices, such as LSI (Large Scale Integration), IC Memory and Bubble Memory.

This trend leads to the enhancement of processor speed and the capacity of a switching system.

External memory devices, e.g. magnetic drums or disks are being replaced by these static memory devices which need less maintenance manpower and increase system reliability. Another outcome of this trend is the small computers which are referred to as microcomputers. These miniature computers contribute to OA (Office Automation) devices and also give intelligence to communication terminals and switching system peripherals.

Associated with this, however, the greater stabilization of CVCF (Constant Voltage & Constant Frequency) and larger scale power supply is necessary for new exchanges.

(3) Software Technology--Stored Program Control (SPC)

The most innovative development in the switching field is the introduction of computerized exchanges with functions controlled by programs stored in the processor memory.

The SPC concept has brought about various enhancements in exchange functions. Since complex control can be realized by software, new signaling systems or communication protocols are being developed and various new and advanced service features have been addded to basic switching functions. All switching systems developed and introduced hereafter will be SPC exchanges.

As mentioned above, the introduction of the SPC concept has many beneficial effects, however, SPC exchanges have the possibility of total system down. This is because a huge number of program steps written manually are included in the software of an exchange and the flexibly rewritable memory can be damaged by an error or bug executed by a processor at enormous speed.

In order to realize high reliability in switching systems, a number of countermeasures have been developed, i.e., some redundancy is given to the system configuration and special control programs are developed for automatic reconfiguration of the system. Another trend is directed toward the distribution of controls. In order to avoid spreading the extent of damage to the total system, programs are written in packaged modules with specified interfaces. Also, hardware is divided into several processors or control devices. Distributed control can be categorized into two concepts, i.e., load sharing and function sharing. In the first concept, the traffic load can be shared by control units with the same function. This concept is realized in a building unit system. In the second, each unit has different software and is interconnected to the others through a specified interface.

A more fundamental point is to reduce the number of bugs in the software itself or to purchase sufficiently debugged programs. In the introduction of many exchanges, one system should be used for a debugging center and also for training purposes.

As technology progresses, communication system hardware will be manufactured by automated processes and costs will be remarkably reduced. However, the production of programs will be still done by humans for a considerably long period of time although effort is being made on the automation of software production. Since a large amount of software is required and its production and maintenance costs are increasing, a more effective software development system and efficient testing methodology are necessary for modern technology in this field.

One solution has been sought in the development of high level languages. Software for switching systems has been written in machine-oriented languages called assembly languages and these vary from machine to machine. High languages require more processing steps and time. However, processor speed enhancement as described in (2) is progressing to this development and international standardization will be carried on for more efficient software development.

In summarizing the above-mentioned conditions and considering that software is related to human creative activity, it is clear that developments in switching technology will become the software technology of the future.

5.1.2 Telephone Switching

(1) Digitization of Telephone Networks

The telephone service has a history of 100 years during which time a vast analog network has been built. The network expansions are a footprint of the technological development. From the standpoint of transmission, the commûnication quality has been greatly enhanced by prominent advances made by microwave transmission systems and coaxial cable systems in domestic traffic and by satellite telecommunications and submarine coaxial cable systems in international traffic. The technology level for analog-based technology has nearly reached its limits. In terms of switching technology, automatic connection has become possible through the enhanced quality of switching components and advances in control technology, permitting quick and stable services to be offered. The telephone demand is increasing at a rapid speed through enhanced telephone network services, horizontal expansion of economic activities, and development of social activities.

The PCM theory was invented in 1937. The invention of the transistor and advances made in research of high-speed pulse technologies have permitted digitization of transmission lines. The development of LSI technology that has been developed to operate computers at faster speeds and in large capacities has allowed economical use of digital switching systems in telephone services in which analog switching equipment has maintained a predominant position.

Digital networks comprising digital transmission lines and digital switching systems offer the following advantages:

① Quality degradation of a transmission line is caused only by quantization noise during A/D conversion, and noise, integration of level variation, and transmission losses that are present in analog transmission can be eliminated. Therefore, the quality degradation caused by transmission distance and the number of links is extremely low, assuring high-quality communications.

(2) Digital switching systems realize large-capacity transmission lines economically. The internal loss probability is extremely low, and specific speech paths can always be connected in a fixed form.

3) Because the transmission quality degradation is low, limitations on the number of connecting links can be more lenient, permitting the building of a flexible network configuration in conjunction with the high functions of digital switching systems.

(4) Digital communication lines at 64 kbps can be offered between subscribers, allowing non-telephone terminals to be connected to them such as data and facsimile terminals. Compound services combining telephone will be possible.

Digitalization of telephone networks has aggresively been undertaken in various countries since the second half of 1970. Non-telephone services will also be offered by telephone networks when digitization progresses. Therefore, this will have to be considered in order to permit systematic operations with other service networks when digitizing the telephone network.

(2) Switching System

Telephone switching equipment has advanced from step-by-step to crossbar equipment within a common control and stored program control systems and on to Fe-reed switching equipment. They are called analog switching equipment because, in all instances, voice is switched in an analog form as it is. Advances in LSI technology have permitted the development of economical and large-capacity digital switching systems offering abundant functions.

The digital switching system converts voice into 64-kbps digital information (PCM signals) and performs time division multiplexing. Multiplexed lines are called a highway, and time slots equivalent to channels are allocated to digitalized voice information. These time slots are switched by T (time) switches to realize the switching function. T switches are configured by a memory, and the number of channels that can be switched by one switch is restricted by the memory read/write speed. Several T switches are installed, and S (space) switches are connected between T switches to realize a large-capacity speech line. T switches are used to switch channel time slots on a highway, and S switches are used to switch channels between highways. S switches are built in LSI gate matrices.

The digital switching system is of a SPC (stored program control) system employing function and load distribution, which simplifies program architecture, enhances the function addition flexibility, expands processing capacity, and improves reliability.

The digital switching system is a basic structural element of the digital network, and its external conditions such as functions and performance must conform to international standards. CCITT SG XI is promoting standardization of digital switching systems throughout the world, and new developments require attention in conjunction with the development status in various countries.

(3) Signalling System

The common-channel signalling system is a signalling system matching SPC-type switching equipment. Signal links independent from speech paths are high-speed data circuits, and a signalling network is built between switching equipment. The common-channel signalling system offers the following advantages compared with existing speech path associated signalling systems such as CCITT No. 5 and R_2.

① High signal transfer speed to shorten the connection time.

② High-class network operation will be possible as abundant information can be transferred.

③ Signal equipment is not needed for each speech path, and switching equipment cost can be lowered.

The CCITT signalling system No. 6 is of a common-channel signalling system for telephone for domestic and international traffic. It is being used in more areas. The signal-link transmission speed is 2400 bps, and digital transmission by a digital version and analog transmission are possible.

As a common-channel signalling system for use in digital networks, the CCITT signalling system No. 7 has been standardized. The signalling system has a user part (UP) to identify the service type. It is a universal signalling system that can be used in any type of service anticipated to be offered in the future. UPs for telephone and some data have already been standardized, and research and development in this field will progress further to make them into a central signalling system in IDN (Integrated Digital Network).

(4) Digital Telephone Switching Technology

Once the network is digitized, the basic technology related to it can be commonly applied to all service networks. Technology related to the digital telephone network for the moment will be described.

(a) Network Synchronization

In a digital network, all switching equipment and transmission paths in the network have to be operated by the same clock. The frequency is synchronized by the slaved synchronization method to slave the entire network to the master station clock and by plesiochronous operation, in which individual switching equipment and transmission lines have high-accuracy clocks. In general, the former system is used in domestic networks that are operated by one communication entity, and the latter method, in international networks which require equal relations among countries. A clock accuracy of approximately 10^{-11} is required.

Differences in clock phase due to jitter and wandering have to be compensated for also. In general, phase differences are corrected by installing a phase synchronization memory in the switching equipment.

(b) Interface Between Switching Equipment and Transmission Line

Figure 5.1.2.1 shows interface between transmission lines and switching equipment when analog and digital transmission lines are installed in parallel.

Three types of interface are available, types A, B, and E. Types A and B are for digital interfaces and are regulated by the CCITT Recommendations Q.503. There are two methods to accommodate analog circuits. One method is to connect them to digital interfaces A and B after digital-multiplexing outside the switching equipment as in circuits V and VI. In the other method, circuits are connected to a digital switching system through interface E in an alalog form as in circuit VII for digital multiplexing in the switching system. The latter method permits piling to any multiplexing method inside the switching system, and the multiplex circuit configuration will have freedom. The analog interface E is regulated by the CCITT Recommendation Q507.

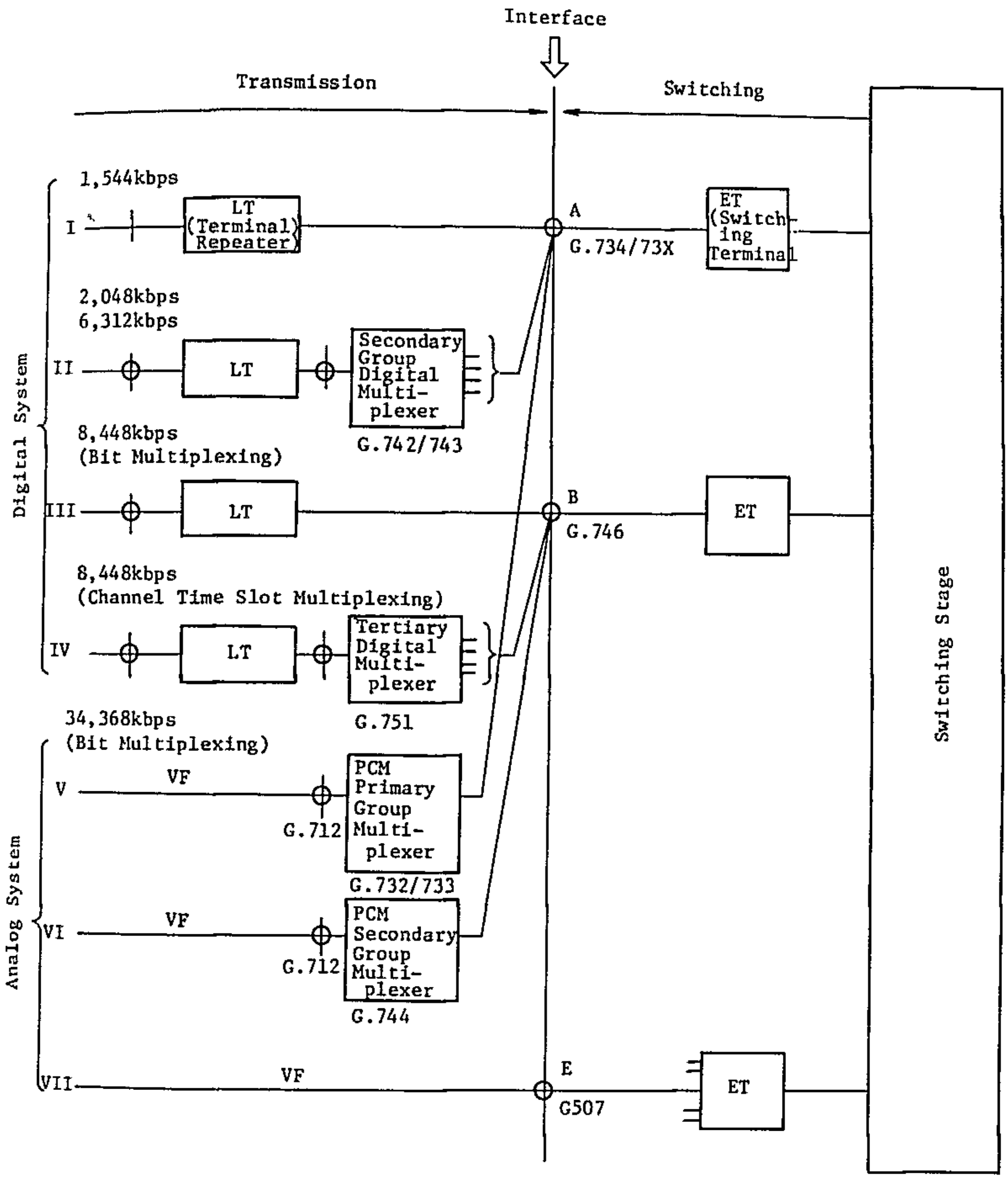


Fig. 5.1.2.1 Interface Between Transmission Lines

(c) Echo Control

In a long-distance speech circuit, the signal propagation time reaches as much as several hundreds of milliseconds, and an echo disturbance is generated. An analog international circuit has an echo suppressor. Its operating principle is to cut off the echo return path with a switch, not offering subscribers a more pleasant sound.

The echo canceller is an ideal apparatus to completely eliminate the shortcomings of the existing echo suppressors. The echo canceller does not interfere at all even if telephone circuits are used for non-telephone services. The echo canceller utilizes an algorithm technique and matches well in a digital network. A compact and high-performance echo canceller is being developed, assisted by advances made in LSI technology.

A large number of countries are installing digital echo suppressors in digital switching systems. However, digital echo cancellers will be used as maincurrent equipment.

(d) Digital Signalling Equipment

Until the technology and hardware of digital networks mature, digital telephone switching systems will continue to use the conventional signaling system that utilizes pushbutton (PB) and multi-frequency (MF) signals. Digital conversion specification conditions are recommended for part of the signalling systems (CCITT No. 6, R2), and specific time slots are allocated to signal information, permitting ordinary digital processing. However, other signalling systems (CCITT No. 5, domestic signalling system) are converted directly into digital codes as in voice without digital conversion. Because the signalling system does not perform digital conversion, PB, MF, and line signals directly digital-coded are not analog-converted in the digital switching system, and equipment is used to receive and discriminate the signals as digital codes and to directly generate digital signals and transmit them. Receiver equipment is divided into a digital filter and scattered Fourier-transform systems. The former is used when relatively high accuracy is required, such as receiving PB signals. Transmission equipment uses digital oscillators. Signals are stored in the memory in the form of digital codes and are read from storage when sending them.

5.1.3 Telex Switching

The rapid growth of international telex service has led to the establishment of a worldwide telex network. In accordance with this, telex switching technology has developed to such an extent that no innovative technique in this specific field might be said to be left for the future.

A recent trend is directed toward the enhancement of service facilities and interworking with other networks. In the following paragraphs, in addition to these topics, some views will be introduced on the switching scheme which is specific to telex switching and lastly on future service which is supposed to take the place of telex service itself.

(1) Telex Switching Scheme

Telex exchanges which will be introduced in the future are supposed to be fully electronic SPC systems with time division switching schemes. There are several types of time division switching systems which have been adopted among systems already developed. They can be categorized as follows in the light of the unit of information transfer in each switching time slot;

- (a) Character Switching
- (b) Bit (Element) Switching
- (c) Sampled Pulse Switching
- (d) Polarity Reversal Switching

(a) and (b) have an inherent signal regeneration facility which, on the other hand, is accompanied by so called switching delay corresponding to the duration of each character or element. This facility is code and speed dependent and lacks signal transparency.

(a) has been widely adopted since the first era of SPC exchange because it could give the possibility of easy implementation of a large scale system.

At present the CCITT dicussion tends not to adopt (a) because it increases the transmission delay caused by international links relayed in tandem.

(c) and (d) are code and speed transparent systems but they lack immunity against signal impairment because they don't have an inherent regeneration facility.

(c) requires the highest processing speed and special arrangements for large capacity.

(2) Signaling

CCITT has standardized so far Types A, B, C and D as signaling systems used for international connection. Of these four, Types A and B which are standardized in Recommendation U.1 are conventional systems and widely adopted among many countries.

Type C was proposed by the U.K. and standardized in Recommendation U.11. Type C is aimed at high and efficient usage of international direct circuits in conjunction with automatic alternative routing and transit switching of overflow traffic.

Type D has the same origin as the development of a signaling system for public data networks, X.70, which was proposed by West Germany and has accordingly a close commonality with Type D.

Type D is designed for SPC exchange and has a lot of advanced features including advantages adopted in Type C, e.g., overlapping of the forward-path selection for speeding-up the call set-up and the identification of transit centers for international accounting purposes.

Recent discussions on signaling in SG IX are focused on the interworking between conventional signalings and Type C or D. One outcome of these dicussions has led to a view not to recommend Type C for application to a new exchange.

Since Type D has been revised in every study period, some countries implemented different versions of Type D. No commercial international telex connection with Type D signalling has been officially reported in a service integrated telex/data switch.

(3) Advanced Services

Telex switching is already a matured technology and from the viewpoint of service enhancement many countries are active in introducing additional facilities into the basic switching function. The following are user facilities which are supposed to be taken into consideration in future networks. They are mainly categorized into facilities provided 1) in real time, and 2) on a store and forward basis.

1) Facilities provided in real time

(a) Abbreviated dialing (Short code selection)*

(b) Direct call (Call without selection signals)

(c) Chargeable time information (Indication of chargeable duration)

(d) Camp-on

(e) Call redirection: RDI

(f) Changed address interception: NCH

(g) Announcement service (Recorded message)

2) Facilities provided on a store and forward basis

(h) Store and forward

(i) Multi-address call

The facility (h) is at present on the way to standardization in CCITT SG IX.

* ( ) indicates a terminology used in CCITT

(4) Interworking with Other Networks

(a) INMARSAT Network

The service transition to INMARSAT from MARISAT enabled the existence of multiple shore stations for one oceanic region. When telex service is offered using a self-owned shore station, the interworking between the international telex network and the INMARSAT network has to be considered. As signaling conditions for the interworking are already standardized as CCITT Recommendations U.60 and 61, some specific points for its implementation are described in the following.

For the interworking between a shore station and a gateway station, suitable signaling for each network could be chosen by each operating agency. Implementation could readily be made by adopting signaling similar to that used for the interworking with a domestic network and by regarding the INMARSAT Network as a domestic tandem exchange. Signaling conversion, e.g., satellite access code is necessary at the shore station with a character storing function which compensates for the instability of a maritime satellite channel.

(b) Teletex Network

The future of telex largely depends on how widely and rapidly Teletex service develops worldwide. In principle, as a recorded communication, Teletex is similar to telex, however, it has more advanced features as follows:

i) higher communication speed: 2400 bps

ii) wider combination of character repertoire: Coding I.A. No.5
- Basically uses the roman alphabet, small and capital letters, etc.

iii) automatic memory to memory transfer
- possibility of simultaneous reception and preparation of text

ix) printing on pages

These attractive features are considered to provide the foundation for the replacement of telex by Teletex. In addition to the above, CCITT Recommendation F.100 stipulates the capability to interwork in both directions with the telex service by means of a conversion facility (CF).

In addition, the Recommendation entrusts the choice of a network for carrying Teletex traffic to each operating agency. Three possibilities are considered:

i) Circuit Switched Public Data Network (CSPDN)

ii) Packet Switched Public Data Network (PSPDN)

iii) Public Switched Telephone Network (PSTN)

Therefore the interworking between Teletex terminals must be independent of the network characteristics, and protocols of terminals have to be developed so as to meet this requirement. The layered model of communication protocols clearly gives demarcations of each processing procedure. Related Recommendations are as follows:

S.62 Control Procedures for the Teletex Service
S.70 Network-independent Basic Transport Service for Teletex

Since the interworking between telex and Teletex is made with different level protocols, CF which interfaces two networks must be capable of protocol conversion in each level together with a store and forward facility for each message.

These two services have a close relationship and interworking should be achieved when the Teletex Service first begins. At this moment it is difficult to anticipate how long and to what degree such interworking will penetrate but it might be that this is a necessary arrangement for the transition and future development of telecommunication networks.

5.1.4 Data Switching

(1) General

Developments in computer technology have deeply penetrated the field of telecommunications, and given birth to new communication media and computer to computer or terminal data transfer. In the initial stage, the general trend is that this is carried out on a point-to-point basis via leased circuits. As data traffic increases and has multiple destinations, the switching concept is introduced and switching is sometimes performed on a leased circuit basis. As the number of computers increases, the concept of a public data switched network is introduced. A number of countries have constructed domestic data networks and the development of an international public switched data network has begun.

In data switching, both ends of communication are terminated non-human assisted machine and there are various types of data transmission exchanged, e.g., data base access, file transfer, bulk data transmission, facsimile, inquiry-response, etc.

This machine-to-machine communication is supposed to require the advent of a new network with advanced capabilities such as higher speed and quality together with flexible network operation.

According to the data transfer unit and the method of storing, the data switching scheme can be realized in three categories as follows:

Message Switching (Store and Forward)
Circuit Switching
Packet Switching

Their features are as described below.

(2) Switching Scheme

(a) Message Switching (Store and Forward)

Message switching has been conventionally applied to telegram switching and recently to message switching of leased circuits, in which a simultaneous and two-way message flow is not required on an end-to-end basis. Each message is stored in the buffer storage or, in the conventional method, recorded on a paper tape in a switching station and then forwarded to the next station according to its address. Since a circuit can be released after a message has been stored and used for another message transmission, the circuit efficiency can be highly increased.

Addition to this, additional data processing of the stored information is possible and enables customers to enjoy advanced service facilities. On the other hand this scheme requires a specific amount of buffers and causes delay in message transfer.

(b) Circuit Switching

Circuit switching has been conventionally used for telephone and telex which are based on conversational communication between customers. This technique is also applicable to data switching. After a call is established, a circuit is maintained during the call on an end-to-end basis, regardless of intermission in data flow. Since the existing international standardization entrusts the error control facility to the customer's protocol, transmission through this type of network is not of comparatively high quality. It is generally considered that this switching scheme is suitable for transferring a large amount of data. Circuit switching has been adopted in public switched data networks established in West Germany, Scandinavian countries and the Japanese domestic network. However, its application to international data switching is limited for the time being and its future development is not yet clear.

(c) Packet Switching

i) General

Packet switching technology has been adopted in the recently developing international public switched data network (See Fig. 5.1.4 (2)) which has extensively applied software control technology in communication network management. This is a type of store and forward method, which, in principle, leads to the efficient use of expensive international transmission lines.
This will be valid as long as memory cost remains much lower than that of international transmission lines.
What is peculiar to this technique is that the switching is performed on a "packet" basis. A packet is a fraction of one message which is divided into a standardized format. The length of switched information is made smaller, e.g. 128 or 256 octets* to the transfer delay and decrease the amount of storage in a switching node. This can implement the efficient, flexible handling of a message in the network. This formated "packet" unit is also used as control information such as call set-up, clearing, etc.

* one octet: eight bits

Moreover, interoffice transmission lines consist of high-speed links through which packets are transferred at high speed, the switching delay is extremely short and the exchange can put forward the received packets directly from the main memory to outgoing links without storing them in external memory devices. This is a different technique from that of conventional message switching. Additionally, an error control facility is provided in the forwarding packets and high-quality transmission is realized; e.g. bit error rate: 10^{-9} to 10^{-10}. Speed conversion is also possible in this network.

Another attractive feature of packet switching is the introduction of a new charge system; in addition to conventional call duration counting, the amount of information carried, i.e., the number of packets, is counted and combined with the conventional charges.

Due to these advanced features, packet switching networks will meet the requirements of computer communication and widely develop throughout the world for the establishment of a new international data network.

ii) Advanced Communication Mode : Virtual Call

In packet switching, there are modes to conduct communication, i.e., virtual call service, permanent virtual call service and datagram service. The datagram service was the original status of packet switching. However, in the field of international packet switching, worldwide trends were directed toward the standardization of virtual call service in pursuit of the establishment of a flexible, advanced network.

When a call is set up in the virtual call service, some packets are sent and a "logical" link is set

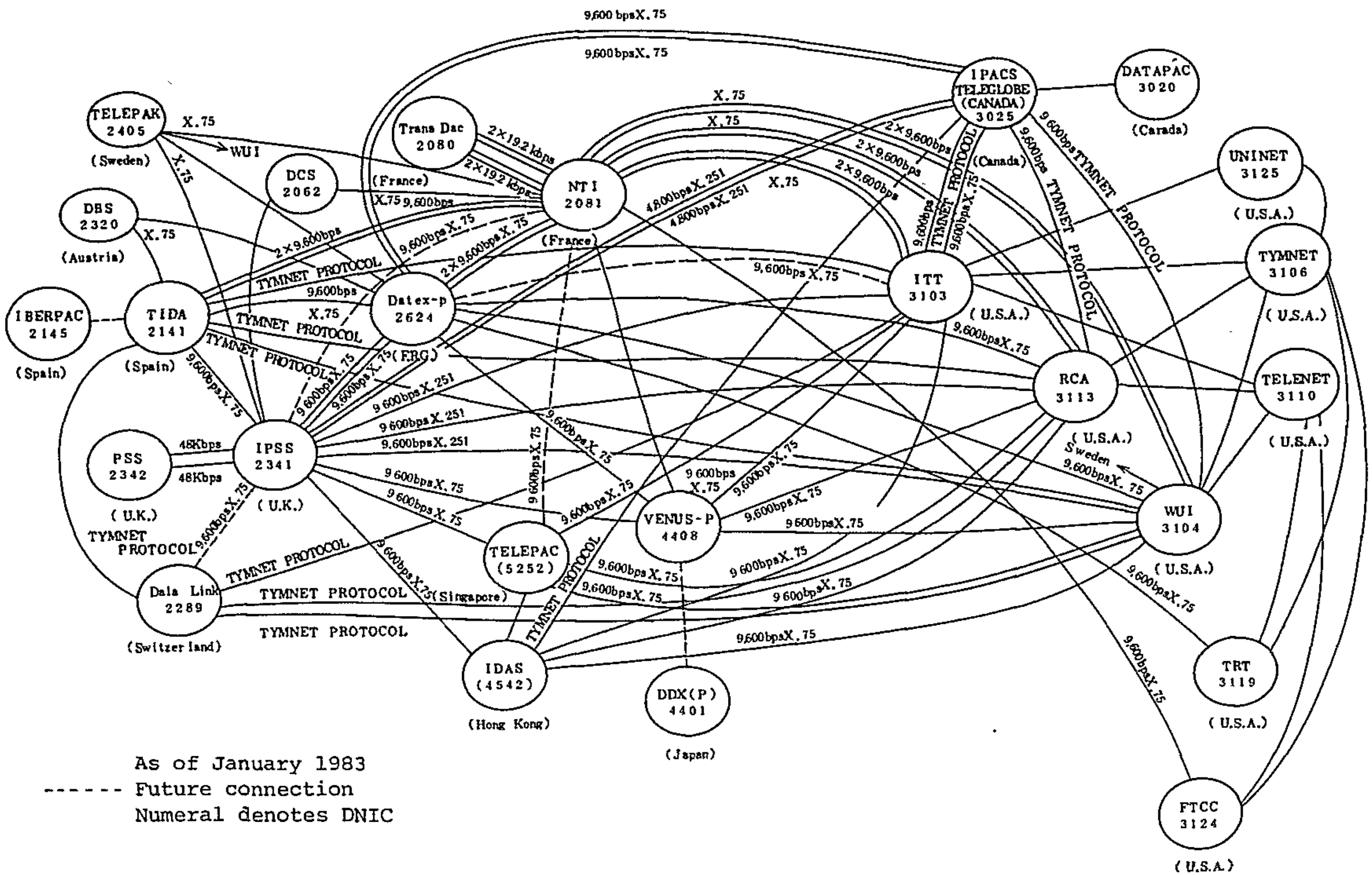


Fig. 5.1.4.2 Development of International Public Switched Network

up. Memorized information in each switching node controls a packet flow and the physical connection between switching nodes can be used for different virtual calls. From the customer's viewpoint it looks as if a specific end-to-end connection was established for his communication as in circuit switching. The permanent virtual call has almost the same mechanism as the virtual call except that a logical link is always maintained without transmitting control packets. Therefore, this service has the features of a leased circuit.
Virtual call service has another advanced feature, i.e., "flow control" in network management to prevent overflowing of buffers which may cause catastrophic overloading of the network. This is an attractive feature for communication carriers to establish a flexible and highly reliable international network. This is the reason why CCITT standardization efforts were concentrated on the virtual call service and the international public data switched service was started from this service.

(3) Standardization of Interfaces: - Protocols

In data communications, there are various kinds of terminal equipment, from character terminals to host machines with communication control unit interface. This is remarkably different from the simple and universal interface which has been adopted in telephone or telex and is operated by a human. Machine-to-machine communication requires common, rigid characteristics to specify the interface and cope with all complex and abnormal conditions.

These are the reasons why standardized interfaces referred to as "protocols" are considered very important.
The protocol is the integration of two concepts: one is referred to as signaling in conventional switching, the

other is data link control procedures in the computer communications field.

Protocols have the following specifications:

i) Set-up procedures of a circuit and a link

ii) Data transfer procedures including error and flow control

iii) End-to-End control procedures

As is shown here, protocols are required to include many functions and are supposed to be very complex. In order to effectively simplify and organize them, protocols were categorized according to their functions as shown below. This is the concept of a "layered model" or "reference model" of protocols. A schematic diagram and its application is shown in Fig. 5.1.4.3.1.

Level 1. Physical Layer

The physical and electrical interface between devices such as a terminal or switch and the transmission link.

Level 2. Data Link Layer

The procedure to control data transmission between devices connected by one transmission link such as link set up and error control.
Example: HDLC and Frame level of CCITT Recommendation X.25 and X.75

Level 3. Network Layer

The procedure to control end-to-end connection, e.g. call set-up, clearing flow control.
Example: Packet level of X.25 and X.75

Level 4. Transport Layer

The procedure which enables end-to-end transparent data transfer independent from the level below 3, that is, regardless of PSDN or CSDN.

If we look further into the functions of terminals or computers, higher levels than the above are categorized into levels 5, 6 and 7. They depend on service features such as terminal to host, Teletex, etc.

The results of recent CCITT SG VII (New Data Network) activities can be shown as several Recommendations related to packet switching. The relationship between packet switched networks and typical Recommendations is shown in Fig. 5.1.4. 3.2.

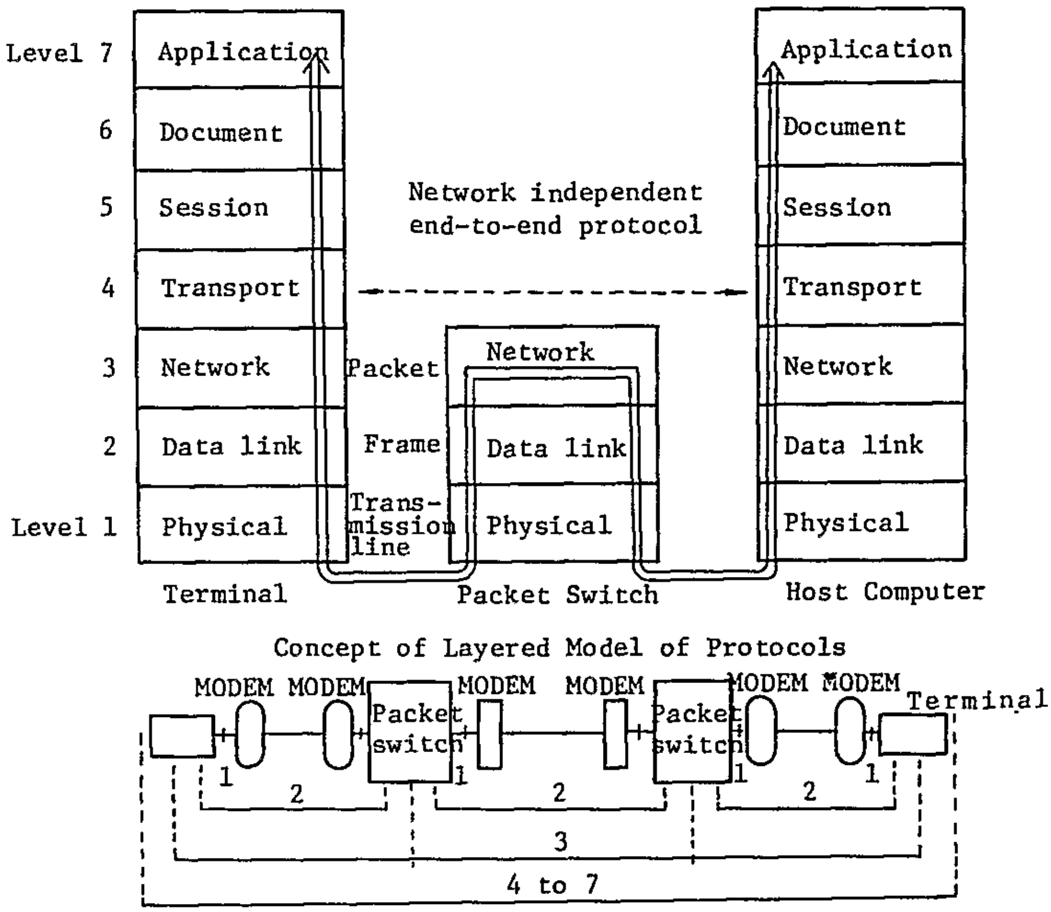
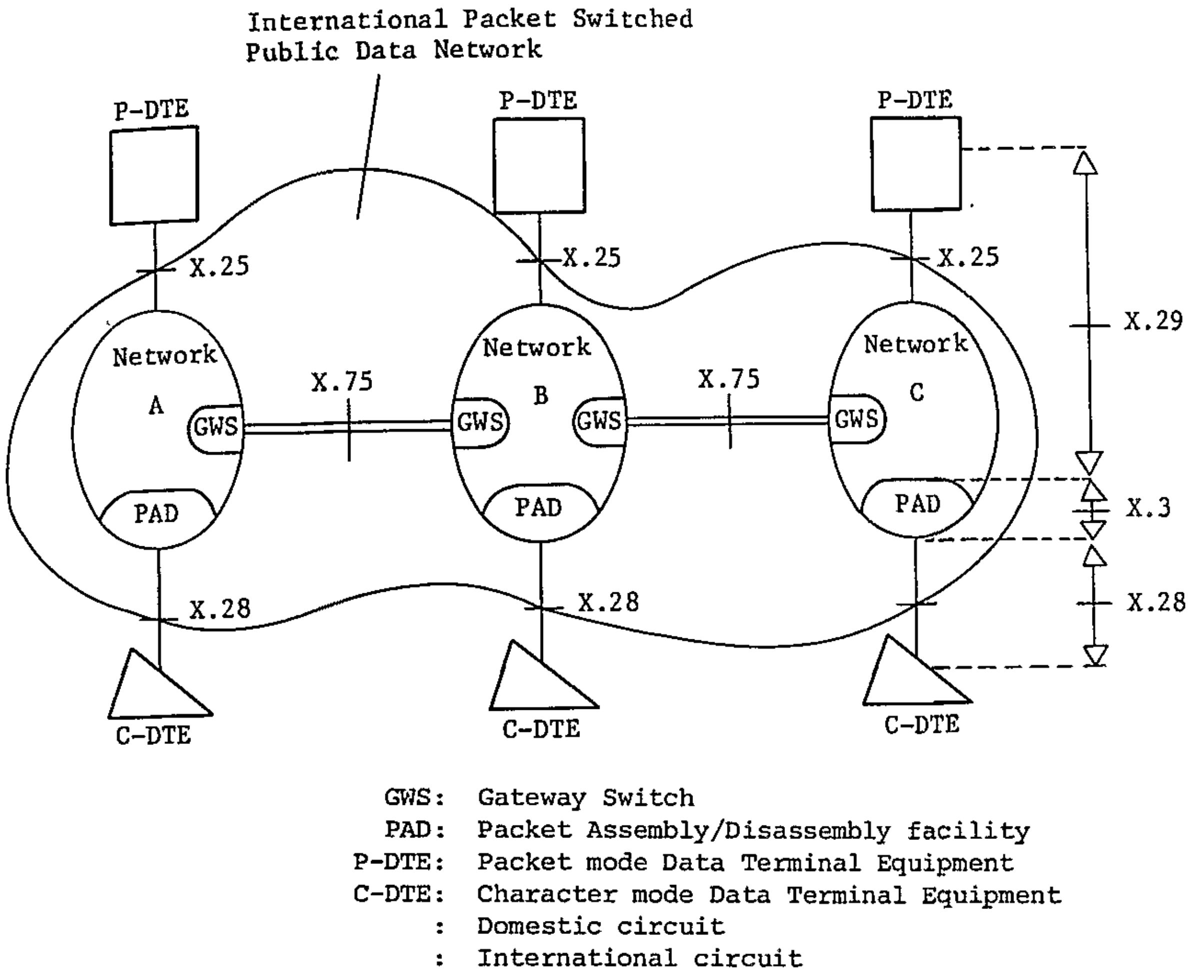


Fig. 5.1.4.3.1 Application of Protocols



X.3 : Packet assembly/diassembly facility (PAD)

X.25: Interface between data terminal equipment (DTE) and data circuit-terminating equipment (DCE) for terminals operating in the packet mode on public data networks

X.28: DTE/DCE interface for a start-stop mode data terminal equipment accessing the PAD

X.29: Procedure for the exchange of control information and user data between a packet mode DTE and a PAD

X.75: International interworking between packet switched data networks

Fig. 5.1.4.3.2 Relationship between Packet Switched Data Network and CCITT Recommendations

(4) Numbering Plan

In order to facilitate the introduction of public data networks, the international numbering plan for public data networks is established as CCITT Recommendation X.121. The calling format using this numbering is as shown below.

<———— International Data Number ————>

P + [DNIC] + [Network Terminal Number (NTN)]

(4 digits) (Up to 10 digits)

or

P + [DCC] + [National Number (Starting with 4th Digit of DNIC)]

(3 digits) (Up to 11 digits)

DNIC = Data Network Identification Code

DCC = Data Country Code (The DCC list is prepared for countries which have code assignments for other services)

P = International Prefix

Fig. 5.1.4 International Calling Format

The format of DNIC is as follows.

ZXXX

- ZXXX — Data Network Identification Code (DNIC)
- Fourth digit — Network digit
- First three digits — Data Country Code (DCC)

X denotes any digit from 0 through 9

Z denotes any digit from 2 through 7

0 and 1 are reserved.

8 and 9 are for interworking with telex and telephone networks.

(5) Message Handling Systems (MHS)

As the development of the international public switched network has begun and the application of Teletex and facimile terminals using the new, high-quality network is being studied in accordance with the progress of office automation (OA), international standardization is directed toward a more advanced processing facility of transmitted messages stored in a network file. The definition of message covers a wide range, e.g. texts, facsimiles, digital voice, etc. This trend is very similar to what is happening in conventional telex service.

MHS will offer non-real-time and non-conversational mode services. Main service features are categorized as follows;

i) Advanced delivery service such as multi-address, repeated transmission, redirection
ii) Store and retrieval service such as mail box
iii) Message generation such as file processing and editing

Although the coverage of MHS is still ambiguous, the standardication efforts intend to realize worldwide protocols, e.g. in reference to the Open System Interconnection of ISO. These protocols will be standardized at a level higher than level 4 in the layered model. This means MHS will be an independent network regardless of the type of switched data network.

5.1.5 Terminal Equipment

(1) General

The progress of LSI and software technology has had a great impact on switching systems and networks. The same influence has reached the development of communication terminals. A significant trend is the application of micro-processors and their peripherals to terminal equipment and this has given intelligence and variety to their functions.

This trend originated in the data terminal accelerated by demands for Office Automation (OA). One example is the advent of the word processor with a CRT display and an external storage, such as a diskette. This new equipment has even produced a new telecommunication service, Teletex.

(2) Terminals for Conventional Services

Among conventional terminals with a simple interface with a network like telephone sets, modernization is being continued, e.g., instead of a dialing plate, push buttons are installed and can be used for a data input terminal if the network can offer access to computer files. Another feature is the transition from analog to digital. A digital telephone set will be prepared for the future digital network.

Even conventional telex terminals are being equipped with microprocessors and CRT displays which can implement text editing facilities.

(3) Data Terminal

An effect of data terminal intelligence is to enable the capability of local processing and decrease the load of the host machine. This will lead to the efficient use of computer resources.

The most different aspect of data terminal equipment (DTE) compared to conventional telephone and telex is its variety. If this equipment has an appropriate standardized interface, e.g. communication control units and MODEM's, it can make access to each other through a network. The standardized interface is as described in Section 5.1.4 (3) and terminal-to-terminal procedures are implemented in higher levels. Existing data terminals may be classified as follows;

i) Simple teletype terminal
ii) Word processor

iii) Intelligent terminal
iv) Office computer
v) Online or host computer

(4) Facsimile Terminal

In response to the development of microprocessors, cost reduction of facsimile terminals has been made possible and higher speed terminals are becoming popular these days. CCITT has already standardized three types of facsimile terminals for the conventional analog network, i.e.:

T.2	Group 1	Low speed / six minutes	for ISO A4 document
T.3	Group 2	Medium speed / three minutes	
T.4	Group 3	High speed / one minute	

At present, the Group 4 terminal which is intended for use in public data networks is in the process of standardization. As public data networks develop, demands for higher speed, higher quality and more advanced operation will increase. The Group 4 terminal will meet such requirements.

Although the advantages of facsimile as a graphic and recorded method of communication have been recognized, it has been difficult to provide a public switched service, especially on an international basis. Because various types of terminals had been brought into the commercial market before international standardization was established, the transmission cost was high compared with other recorded communication media. The CCITT standardization shown above has started to overcome this difficulty and will make facsimile a potential communication media in the future.

(5) Terminal Complex--Mixed Mode

As network digitalization proceeds, the trend toward integration of services will be realized and the terminals are considered to comprise a complex of terminals for each service, e.g., mixed mode operation of facsimile and Teletex or digital telephone and data/facsimile transmission.

5.1.6 Future Trends Toward ISDN

As previously described, a major trend of switching technology tends to the wider adoption of such digital techniques LSI and SPC. In the field of transmission, as shown in the following sections, the digitalization which originated 20 years ago with the introduction of PCM systems is being accelerated by the development of fiber optics and milliwave radio systems.

The next stage is a common new trend to combine both digitalized switching and transmission technology to realize a totally digital network called IDN (Integrated Digital Network). This concept is supported by the following favorable aspects:

i) Digital systems mainly supported by the time division multiplexing technique can be increasingly more effective in cost and space as the grade of integration and the processing speed continue to be enhanced. In this enhancement, there is no fixed technical barrier as yet foreseen such as filter devices in analog transmission.

ii) Digital transmission can decrease the number of repeated modulation and demodulation stages and has no inherently accumulated distortion. Accordingly, a great improvement is anticipated in transmission quality.

iii) Digital technology has a suitable adaptability to the introduction of new future services, such as telematic services, sophisticated signaling or advanced maintenance and operation.

The establishment of an IDN will be started first for telephony. In order to carry this out, digitalization in subscriber line transmission is indispensable and difficult to implement economically. Since this customer interface greatly influences service facilities for future service integration, its standardization is very important.

Together with the IDN progress in telephony, other services like data communications or telematique (Facsimile, Teletex, Videotex) will proceed to take advantage of IDN. For a considerably long period of time, the main services will be provided by each dedicated network and access to each other will be conducted by interworking facilities.

The final approach is the consideration that each dedicated network will be integrated into one network which offers various kinds of services. This is the fundamental concept of ISDN. In order to establish ISDN, CCITT is actively working for the necessary standardization. The necessity of standardization has arisen from the following reasons:

i) As future society will be progressively internationalized, it is desirable to standardize the whole network from the viewpoint of network management, manufacturing of systems and user operation.

ii) Digitalization needs to have unified characteristics such as network synchronization and analog/digital conversion.

iii) The future coverage of the digital network is still ambiguous. If each country organizes its network based on independent characteristics, the universal network will not be realized and the approach toward ISDN might be aborted.

According to the outcome of recent work, the definition of ISDN is going to be modified. The new concept will be as follows:

i) The main feature of ISDN is the support of voice and non-voice communications in the same network. A key element of service integration for ISDN is to provide a limited set of standard, multipurpose interface arrangements.

ii) The evolving ISDN may also include, in later stages, switched connections at bit rates higher and lower than 64 k bits/s. Switched connections include both circuit-switched and packet-switched connections and their concatenations.

These proposals will modify the conventional definitions below.

ISDN: an integrated digital network in which the same digital switches and digital paths are used to establish connections for different services, for example telephony and data.

A great deal of effort will be needed to specify international standardization.

Moreover, there are some constraints which must be eliminated in the progress toward ISDN such as:

i) The equipment installed in ISDN becomes so sophisticated and complex that it needs highly advanced engineering, maintenance and operation.

ii) Failures arising in one part of ISDN may affect all services.

iii) It is difficult to decide who will manage ISDN for different organizations and different services.

Although there are many problems to overcome, a number of countries are already introducing digital switches and transmission systems which are considered preparation towards ISDN.

The ISDN concept in the domestic network in Japan is referred to as INS (Information Network System). Experimental field trials has been commenced from 1982 and are to be carried on up to 1984 by NTT. The network configuration for this experiment is as shown in Fig. 5.1.6.

Main steps toward INS is sheduled as follows :

(a) For the time being

The development of dedicated networks for non-voice services, e.g. data and facsimile, and the promotion of digitalized telephone network.

(b) After 1985

The establishment of digital data network and facsimile network all over Japan.

(c) Around 1990

The Integration of non-voice networks. Telephone network will still have hetergeneous modes, digital/analog.

(d) After 1990

Completion of INS with reformation of network structure with:

i) Extension of the coverage of subscriber switches

ii) Enhancement of network dependability by formulating mesh type network with satellite links and loop type with terrestrial links.

iii) Decrease in the number of hierarchical levels.

Principles for this project is based on the following :

(a) Increase of the ratio of non-voice service

(b) Growth of system capacity with economization

(c) Unique tariff irrespective of distance

Thus the realization of ISDN has surely taken a step toward the future.

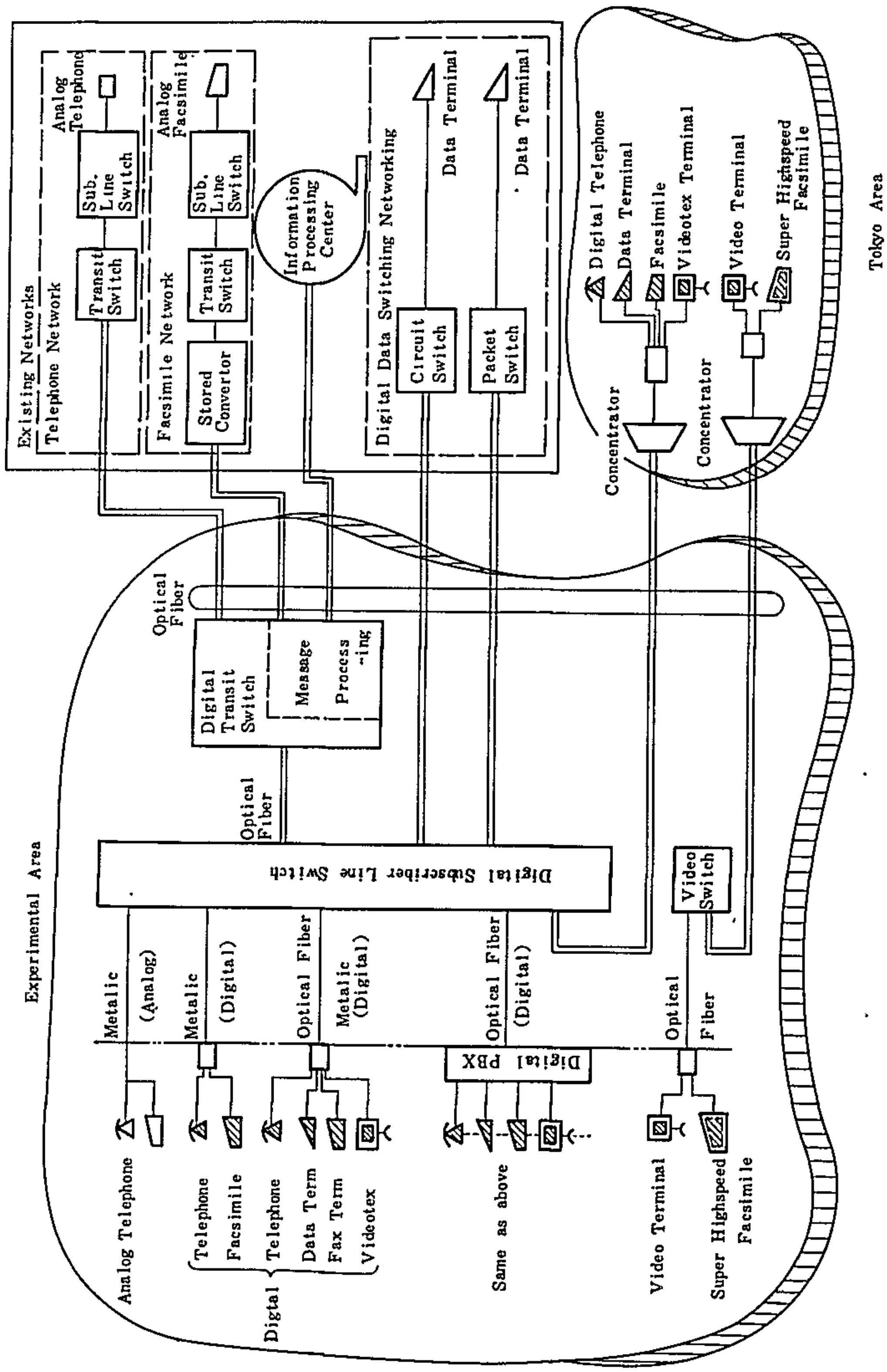


Fig. 5.1.6 Japanese Domestic Experimental Network for ISDN

5.1.7 INMARSAT System

(1) Outline of INMARSAT

(a) Organization of INMARSAT

INMARSAT is an international organization established by the Final Act of the International Conference on the Establishment of an International Maritime Satellite System. It came into being on July 16, 1979 two months after the signing by Canada to the Convention to satisfy the requirement.

The State Parties or the designated entities which signed the Operating Agreement attached to the Final Act are called the Signatories.

The organs of INMARSAT consist of the Assembly, Council and Directorate headed by the Director General.

The Assembly is composed of all the Parties to the Convention and meets once every two years. The function of the activities, purposes, general policy and long-term objectives of INMARSAT, to express views and make recommendations thereon to the Council.

The Council, on the other hand, consists of twenty representatives of the Signatories which have the largest investment shares in the Organization and four representatives of Signatories elected to represent geographical areas. The present Council representatives and respective investment shares are shown in Table 5.1.7.1. The functions of the Council are to determine all the substantive matters of INMARSAT including adoption of policies, plans, and measures for the design, development, construction, acquisition, operation, maintenance and utilization of space segments.

The Director General is the chief executive and legal representative of INMARSAT whose term of office is six years. The structure of the Directorate, which is stationed in London, is as shown in Fig. 5.1.7.1. The number of staff members in the Directorate is 66 as of February 1, 1982.

The Council established an Advisory Committee on Technical and Operational Matters (ACTOM) in order to assist the Council in discussing details of the relevant technical and operational matters.

(b) Purpose of INMARSAT

The purpose of INMARSAT as set forth in Article 3 of the Convention is to make provision for the space segment necessary for improving maritime communications, thereby assisting in improving communication for distress response and the safety of life at sea, efficiency and management of ships, maritime public correspondence services and radio determination capabilities.

The "ship" in this case means a vessel of any type operating in a marine environment. It includes hydrofoil boats, aircushion vehicles, submersibles, floating crafts and platforms not permanently moored.

Article 7 (2) of the Convention permits access to the INMARSAT space segment by ship earth stations located on structures operating in a marine environment other than ships, if and as long as the operation of such earth stations will not significantly affect the provision of service to ships. The "ship earth station" located at the Antarctica bases of Japan and the Federal Republic of Germany have been granted access to the INMARSAT space segment in accordance with the provision above.

The ship earth stations for demonstration purposes as is seen here today are also permitted to have access to the INMARSAT space segment based on a policy established by the Council.

(2) Services and Traffic Forecast

(a) Services to be Offered

Table 5.1.7.2 shows the services to be offered by INMARSAT. Significant demand is foreseen for the broadcast (group call) services and studies are being make extensively by the INMARSAT Directorate and Signatories. The only group call being offered at present is the service announcement made by NCS for the purpose of system management. The future service will include group calls to all ships, to ships in a defined ocean area, and to ships of specific nationalities or fleets. Commercial news services, facsimile service including weather map transmission will be introduced in the near future.

Data transmission services of higher speed will be offered in the near future. The position determination of ships via satellite will be another attractive feature of the INMARSAT system.

(b) Distress and Safety Communications

Distress and safety communications are being handled with top priority in the telephone and telex channels by pre-empting the working channel if required. The Future Global Maritime Distress and Safety System (FGMDSS) projected by IMCO will largely depend upon the INMARSAT system. The satellite EPIRB (Emergency Position Indicating Radio Beacon) will be introduced in the initial INMARSAT system, and the experiment will be carried out shortly by the interested Administrations in coordination with the CCIR.

The case of the Prinsendam reportedly failed to fully use the satellite system because of inefficient terrestrial communications links, and the search and rescue operation was performed with the assistance of conventional radios. IMCO and INMARSAT are now actively studying how to improve the communications means for distress response and safety purposes.

(c) Traffic Trend and Forecast

Fig. 5.1.7.2 shows the statistics for ship earth stations and traffic, together with forecasts based on the data from the MARISAT service. A total of 1,022 ship earth stations in the world have been commissioned and 140 were waiting for commissioning as of February 10, 1982. The traffic growth which is almost proportional to that of ships is rather significant. At the end of 1986, it is expected that about 5,000 ships will be operating ship earth stations in the INMARSAT system.

It may be interesting to note the traffic pattern in the MARISAT era. Fig. 5.1.7.3(a) shows the call distribution by ocean region. In 1981, 77% of telephone and 65% of telex calls were made in the AOR. Fig. 5.1.7.4 (a) and (b) show the traffic growth in each ocean region. The sharp growth in the IOR, where service was initiated in November 1978, should be noted. The traffic pattern in the INMARSAT system may change as ships of a number of countries begin participating in the system. Fig. 5.1.7.3(b) shows the call distribution in terms of call direction in the MARISAT era. Most calls, especially for telephony, are in the ship-to-shore direction. In Fig. 5.1.7.5, it can be seen that the average call length of a telephone call is about 9 minutes and that for telex is about 3 minutes. The long calls from ship-to-ship are to be noted.

(3) Technical Characteristics of INMARSAT System

(a) System Configuration

Fig. 5.1.7.7 shows the system configuration of the INMARSAT system. The radio station installed on board ship is called "ship earth station (SES)", the fixed radio station located on land is called "coast earth station (CES)". The satellite and the associated control stations are called a "space segment". A Network Coordination Station (NCS) is provided in each ocean region in order to assign communications channels.

The Operations Control Center (OCC) is situated at the INMARSAT headquarters in London in order to facilitate the management of such a complicated system. OCC coordinates the CESs, Satellite Control Centers (SCCs) of space segment suppliers, and NCSs. OCC also processes the applications for SES commissioning and type approvals for new SES models.

The SES transmits a 1.6 GHz band radio signal to the satellite which in turn converts the frequency into a 4 GHz band signal to be received by a CES. The CES then converts the signal to an appropriate form to be transmitted to the subscriber via the national switching center. The signal from a land subscriber, on the contrary, is sent to the CES through the switching center, and then converted to a 6 GHz band radio signal and transmitted to the satellite. The satellite converts this signal into a 1.5 GHz band signal and sends it to the SES.

The 1.5/1.6 GHz signals, which are conventionally called L-band signals, will not suffer from ionospheric disturbance, thus assuring high quality communications and instantaneous connection. The frequency bands allocated to the maritime mobile satellite service and the bandwidth available for each space segment are shown in Fig. 5.1.7.6.

(b) Space Segment

The space segment of the initial system will consist of the following satellites; MARISAT satellites leased from the MARISAT Joint Venture of USA, ESA's MARECS satellites, and MCS (Maritime Communications Subsystem) of INTELSAT V satellites. The orbital locations of the satellites have been determined taking into account the major shipping routes and locations of the existing and planned CESs. Fig. 5.1.7.8 shows the coverage areas of INMARSAT satellites together with the locations of CESs which are existing or are planned to be constructed by the end of 1984. Table 5.1.7.3 summarizes the existing and planned CESs.

Fig. 5.1.7.9 shows the operational plan for these satellites. The MARISAT satellites have surpassed their life expectancy projections, but according to the latest report, their fuel is sufficient to keep the orbital inclination angle within the specified limit of 3 degrees until the end of 1983. It is to be noted that the communications capacity of the MARISAT satellite is now saturated in the AOR even though 10 channels are activated.

MARECS A was successfully launched on December 20, 1981 by the European launcher ARIANE L04. After being tested in orbit, the satellite will be put into service in the AOR probably from the end of March.

As for INTELSAT V satellites, four MCSs will be placed into orbit in accordance with the lease contract.

The space segment capacity described above will be made available to INMARSAT by the lease arrangement with each space segment supplier. The responsibility to keep the satellite performance within the specified values lies in each space segment supplier. Major performance characteristics of INMARSAT satellites are summarized in Table 5.1.7.4.

(c) Multiple Access/Modulation Method

In the initial INMARSAT system, the same modulation and multiple access methods as the MARISAT system are used. Table 5.1.7.5 summarizes the modulation/access methods. The telephone channel is operated on a demand assignment basis in the FM/FDMA mode with compandor, while the telex channel is operated in the 2-phase PSK/TDM (shore-to-ship) and 2-phase PSK/TDMA (ship-to-shore) modes. The request from the ship for communications is made through a 2-phase PSK burst signal transmitted on a random access basis. The request from the shore and the channel assignment in response to the request from the ship are made using the information bits pre-fixed to the telex signals in the TDM channel described above. The high speed data transmission of 56 kbps will also be provided. The SES TRD (Technical Requirements Document) specifies this capability in a 4-phase PSK mode as an option.

In the future, the voice activation method, which activates the telephone channel only when speech signals are detected, will be introduced in order to make effective use of the space segment.

(4) Outline of Earth Stations

(a) Coast Earth Station

The technical characteristics required for the INMARSAT CESs are specified in the Technical Requirements Document for INMARSAT Coast Earth Stations. Table 5.1.7.6 summarizes typical RF characteristics of CESs.

A Cassegrain antenna of about 13 m in diameter is used for a CES. Special techniques have been developed to use the same antenna in common for the L- and C-bands. The Klystron amplifier is used for the C- band HPA and a transistor amplifier is used for the L- band HPA. A cryogenically cooled parametric amplifier with a 35 K to 55 K noise temperature or an FET amplifier is used as the C-band LNA. A bipolar transistor or FET amplifier is used for the L-band LNA. Fig. 5.1.7.10 shows a typical block diagram of a CES.

The AFC (Automatic Frequency Compensation) technique is employed at the CES in order to compensate for the frequency drift due to the satellite hardware and the Doppler shift caused by satellite movement. The common AFC scheme will be employed, in which a CES is assigned as the reference station for the AFC pilot transmission in a particular ocean area. The detailed method for this common AFC is being studied by the INMARSAT Directorate.

(b) Network Coordination Station

In order to allow the system to be operated in a multiple CES mode, a Network Coordination Station (NCS) is provided in each ocean region. The NCS is collocated at the CES of Yamaguchi in the IOR, Ibaraki in the POR, and Southbury in the AOR, respectively.

Channel assignment is made on a demand assignment basis. When a subscriber on board ship or on land wishes to place a call for telephone, data, facsimile, or high speed data, a request is made to a CES which asks the NCS to assign a channel to that call. Then, the NCS looks for an idle channel among the pooled channels, assigns and notifies the result to both SES and CES via the common TDM carrier. For the telex call, the CES itself assigns the channel and the NCS repeats the assignment, and notifies the result to the SES via the common

TDM carrier. Therefore, the SES can receive a channel assignment message by only tuning to the common TDM carrier.

(c) Ship Earth Station

The Technical Requirements Document (TRD) for Standard A Ship Earth Stations has been prepared in order to keep the integrity and compatibility of the INMARSAT system. Typical RF characteristics of SESs are shown in Table 5.1.7 (6). The TRD is based on the Technical Specifications for the Ship Terminals for the MARISAT System, and some additional features have been added to it.

The Standard A SES consists of the Above Deck Equipment (ADE) and Below Deck Equipment (BDE). ADE consists of an antenna with a diameter of about 1.2-m, LNA and HPA. BDE is composed of a channel control unit, antenna control unit, modems, telex and telephone terminals, etc.

The standard A SES can make telephony and telex, communications as well as facsimile and data transmission via the telephone channel. The high speed data transmission of 56 kbps can be made available, if optional equipment is installed at an SES.

Table 5.1.7.7 shows the four SES standards which are considered by INMARSAT for implementation, though only the Standard A SES is being operated in the INMARSAT system at present. Some of the other standards may be introduced even in the initial system. Extensive studies are being conducted by the Directorate and Signatories in the INMARSAT Research and Development Program.

The Standard A SES has a G/T of -4 dBK, the antenna diameter being about 1.2 m. The Standard D has an antenna of about 3 m in diameter and G/T of +5 dBK, which would be used for data transmission of various speeds and multiplexed voice channels for oil rigs and drilling platforms. Standard B SES has an antenna of about 40 cm in diameter with G/T of about -12 dBK and is capable of reduced quality telephone communication as well as telex communications.

The Standard C is a low G/T terminal, the G/T being as low as -19 dBK. This standard can offer a telegraph channel only, but may be very attractive for small vessels because of its compact size. It would also be useful for the distress alert system to be introduced in the future.

(5) Future INMARSAT System

(a) Procurement Schedule

The lifetime of the first generation INMARSAT system space segment is 7 years. Therefore, a new space segment will need to be deployed in orbit by early 1988 at the latest. The manufacturing of satellites requires at least 3 years. Therefore, it is considered necessary to place orders for satellites by the end of 1984, taking into account the launch delay margin and the required period for procurement procedures. Design activities of the second generation system have been started in INMARSAT in order to prepare the Request for Proposal (REP) by the end of 1982. Fig. 5,1.7.11 shows the procurement schedule for INMARSAT second generation space segment capacity.

In order to promote studies on technical matters, specifically the future INMARSAT system, the INMARSAT Council adopted a policy for the research and development program. Table 5.1.7.8 summarizes items in the INMARSAT R & D Program.

(b) Fundamental Considerations

(i) Dedicated Satellite vs. Multi-purpose Satellite

If a dedicated satellite is used, INMARSAT will have full flexibility in its planning of the service area, channel capacity and satellite deployment. However, the cost of this sort of satellite would be extremely high.

A multi-purpose satellite, on the other hand, has characteristics which are exactly opposite to a dedicated satellite. If sharing is made with a fixed service satellite such as an INTELSAT satellite, the cost of the maritime communications portion would be rather insignificant compared with the total cost of the satellite as a whole. In addition, the operating cost such as TT&C service will also become relatively small. Neverthless, one has to pay penalties in achieving the principal purpose of the system, since the requirements of the small user may not be fully met.

The sharing with an aeronautical satellite system is worth consideration. Because, if the aircraft engaged in the search and rescue activities were equipped with satellite communications equipment of the same system, a more efficient operation would be expected.

(ii) Coverage

Three satellites can, in principle, cover the entire globe, however, it is difficult to satisfy the requirements for coverage and CES locations at the same time. If four satellites are to be used, one can enjoy full flexibility in choosing satellite locations, because the coverage of adjacent satellites can be sufficiently overlapped. In the four satellite configuration, there may be another advantage, that is, the same freqeuncy band ban be used on the back side of the globe. Trade-off studies will be required between such merits and additional costs for spacecraft and TT&C stations.

The coverage for the polar regions cannot be achieved as long as geostationary satellites are used. In order to solve this difficulty, a synchronous satellite with a large inclination angle could be used, permitting access from those ships in the polar regions during limited hours of the day. Another possible approach to achieve this objective is to use a number of polar orbit satellites. SESs should be capable of tracking such satellites which are not stationary. An overall study will be required from operational and economical viewpoints.

(iii) Use of a Spot Beam

A great number of channels will be required for satellite transponders in the future. The most effective way to satisfy such requirements is to increase the satellite EIRP using spot beams and higher transponder power. Limited ocean areas will be illuminated in this case, therefore, a measure to identify the spot beam area where a particular ship is located has to be developed. A more efficient operation will be achieved if satellite switching between beams is accomplished.

(iv) Introduction of a Digital System

In the initial system, the narrow-band frequency modulation system using a compandor is used for the telephone channel. If digital techniques such as speech encoding and forward error correction are used, telephone service with a reduced quality and 4.8 kbps data service could be provided to an SES with G/T of -10 dBK (Standard B). In addition, if a new SES standard using the same Above Deck Equipment as the existing Standard A system were introduced, the channel capacity would be significantly increased.

The introduction of such a digital system is very promising for the future INMARSAT system. It is, therefore, very important for INMARSAT to seriously consider the future configuration of the system based on the full scenarios of evolution.

Digital communications techniques are expected to play a very important role in the communications field, since the ISDN (Integrated Services Digital Network) envisioned in the near future would be fully dependent on the digital satellite system. The overall studies for smooth transition from the initial system are required.

(v) Multiple Access/Modulation Method

It is necessary to study possible multiple access, channel allocation, and the modulation method for the case where a variety of systems such as Standard A, B, C, and D SESs are to be used. The study should also include the frequency allocation method to prevent intermodulation in the satellite transponder.

Table 5.1.7.1 Member Country, Signatories and Investments Shares

(As of 31 Dec. 81)

COUNTRY	SIGNATORY	EFFECT.DATE	INV. SHARE
$ UNITED STATES	COMSAT	79.07.16	23.36370
$ USSR (INCLUDING BYELORUSSIAN & UKRAINIAN)	MORSVIAZSPUTNIK	79.07.16	14.09217
$ UNITED KINGDOM	BRITISH TELECOM	79.07.16	9.89134
$ NORWAY	TELECOM. ADM.	79.07.16	7.87821
$ JAPAN	KDD	79.07.16	6.99915
$ ITALY	MPT	79.07.16	3.35524
$ FRANCE	DGT	79.10.18	2.88553
$ GERMANY (FED.REP)	BPF	79.10.23	2.88553
$ GREECE	OTE	79.07.16	2.88553
$ NETHERLANDS #	PTT	79.07.16	2.88553
$ CANADA	TELEGLOBE CANADA	79.07.16	2.61717
$ KUWAIT	MINISTRY OF COMM.	79.07.16	2.01315
$ SPAIN	CTNE	79.07.16	2.01315
$ SWEDEN *	TELECOM. ADM.	79.07.16	1.87898
$ AUSTRALIA	OTC	79.07.16	1.67770
$ BRAZIL	EMBRATEL	79.07.16	1.67770
$ DENMARK	P&T ADM.	79.07.16	1.67770
$ INDIA	OCS (GOV. OF INDIA)	79.07.16	1.67770
$ POLAND	MINISTRY OF COMM.	79.07.16	1.67770
$ SINGAPORE	TELECOM. AUTHOR.	79.07.16	1.67770
CHINA (PEOPLE'S REP.)	MARINE COM& NAV.CO.	79.07.16	1.23666
BELGIUM #	RTT	79.07.16	0.60395
FINLAND *	GEN. DIRECT. OF P&T	79.07.16	0.60395
ARGENTINA ¢	ENTEL	79.10.02	0.60395
NEW ZEALAND ¢	POSTMASTER GEN.	79.07.16	0.36277
BULGARIA ¢	STATE SHIPPING CORP.	79.07.16	0.27204
PORTUGAL	RADIO MARCONI CO.	79.07.16	0.20610
ALGERIA ¢	MPT	79.07.16	0.05000
EGYPT	GOVERNMENT	79.07.16	0.05000
IRAQ	GOVERNMENT	80.07.21	0.05000
LIBERIA	GOVERNMENT	80.11.14	0.05000
OMAN	PTT	80.12.30	0.05000
CHILE	ENTEL-CHILE	81.02.26	0.05000
PHILIPPINES	PHILCOMSAT	81.03.30	0.05000
SRI LANKA	GOVERNMENT	81.12.15	0.05000

37 COUNTRIES

35 SIGNATORIES

$: Council Representatives Based on Investment Shares

¢ : Council Representatives Representing Geographical Area

#, * : Council Representatives in Group

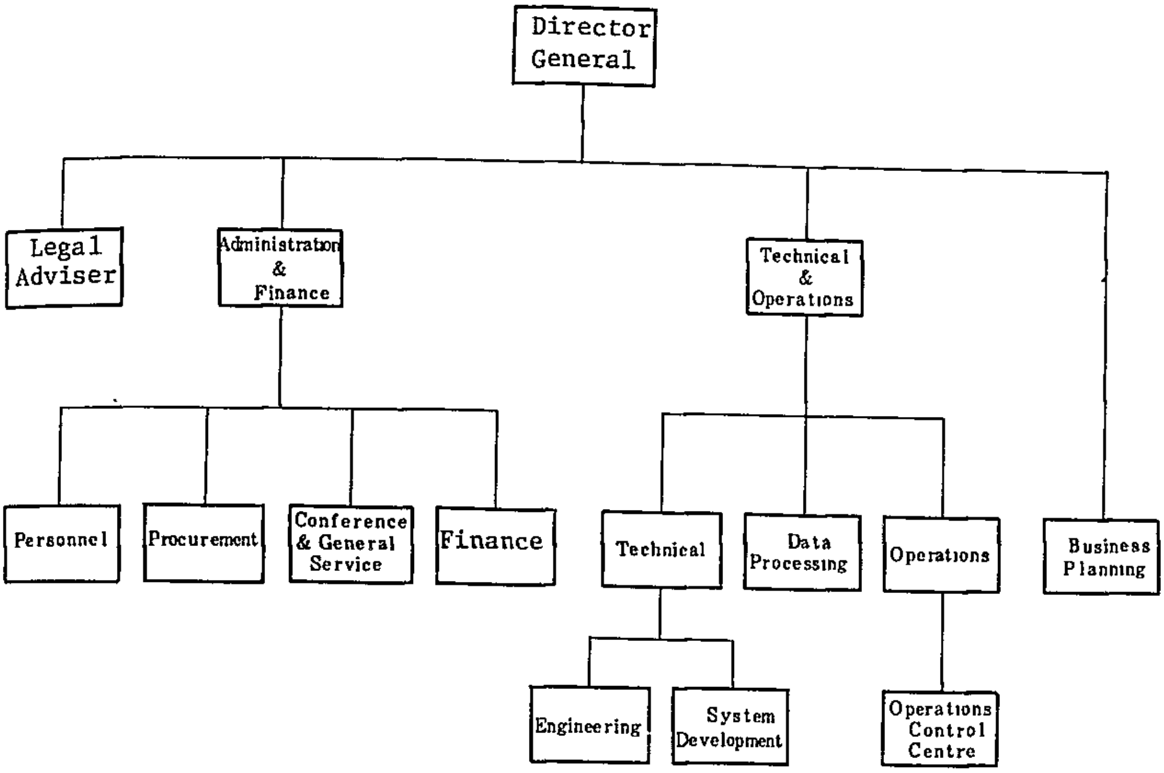


Fig. 5.1.7.1 Structure of INMARSAT Directorate

Table 5.1.7.2 Services to be Offered by INMARSAT

Services	Remarks
Telephone Telex	(Including facsimile) Ship-to-Shore Shore-to-Ship Ship-to-Ship
Data	Up to 2.4 kbps (via telephone channel) Up to 9.6 kbps (for Standard D SES) 56 kbps (option)
Group Call	All ships, Area, National, Fleet
Distress and Safety Communications	Via telephone and telex channels with priority
EPIRB	INMARSAT offers space segment capacity.

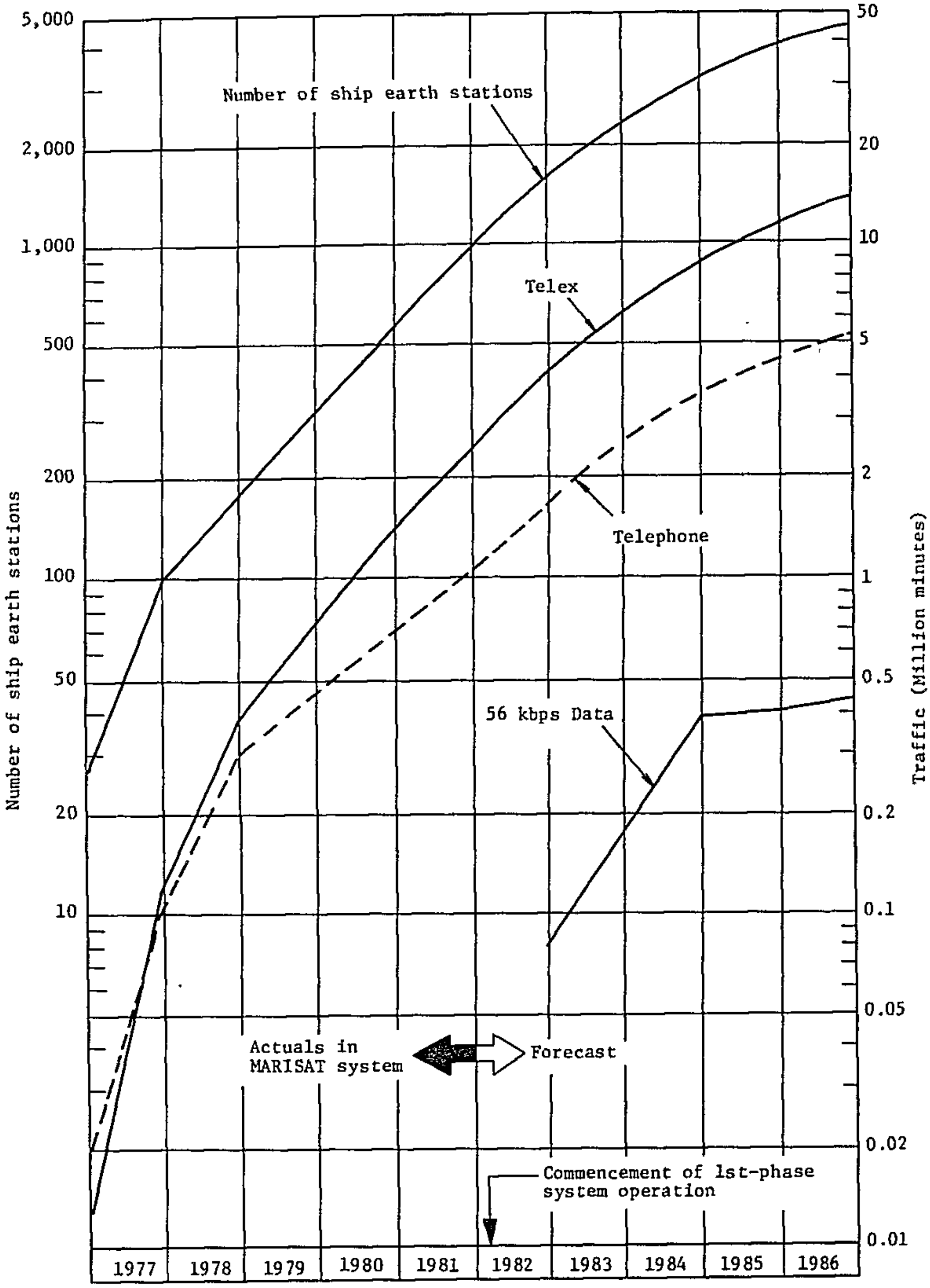


Fig. 5.1.7.2 Statistics of Ship Earth Station and Traffic

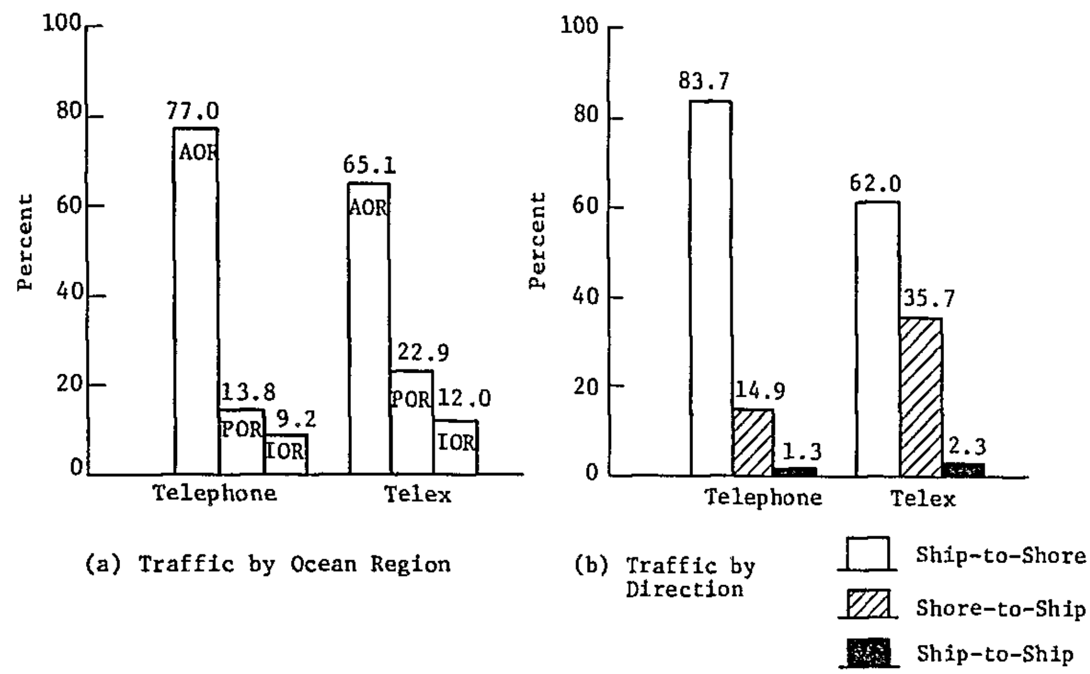


Fig. 5.1.7.3 Traffic Statistics of the MARISAT Service in Call Length

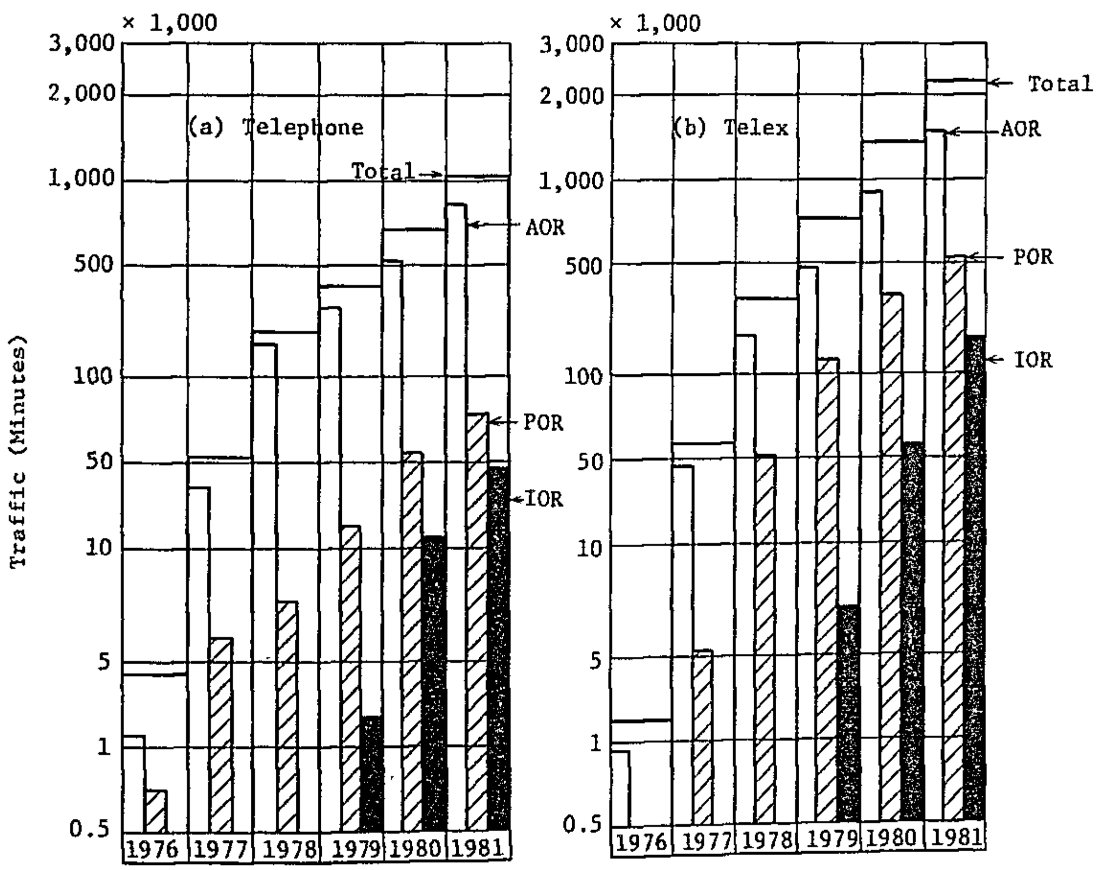


Fig. 5.1.7.4 Traffic Growth in the MARISAT System

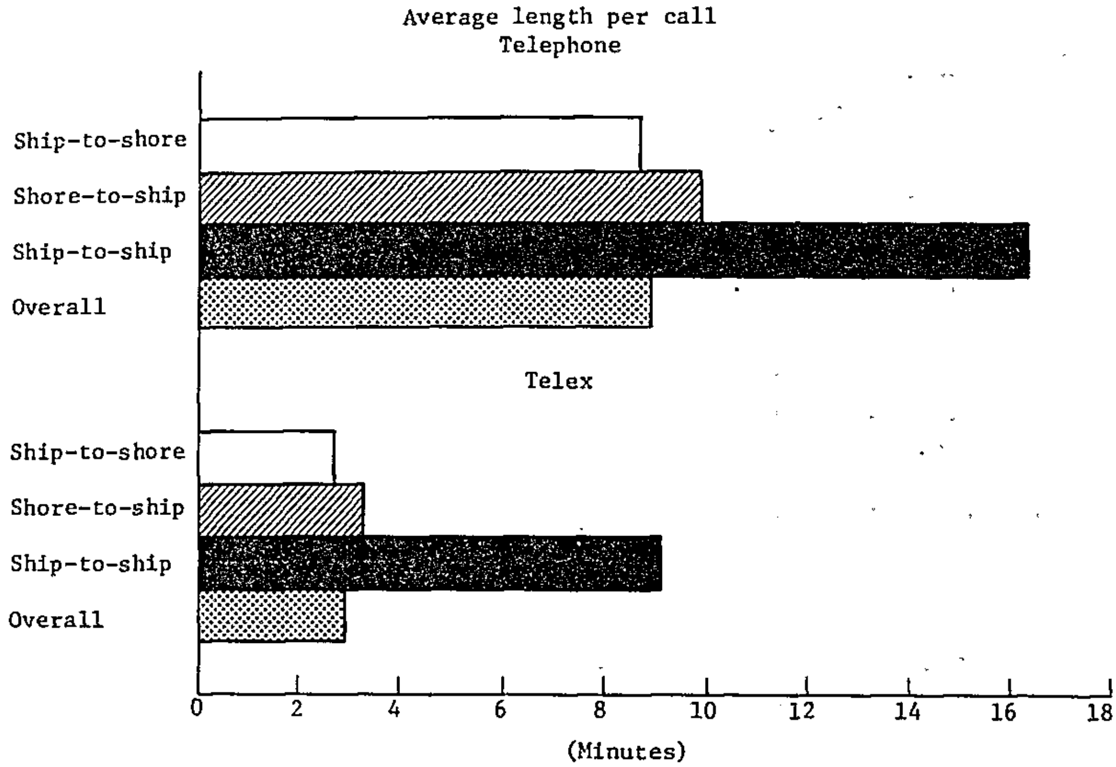
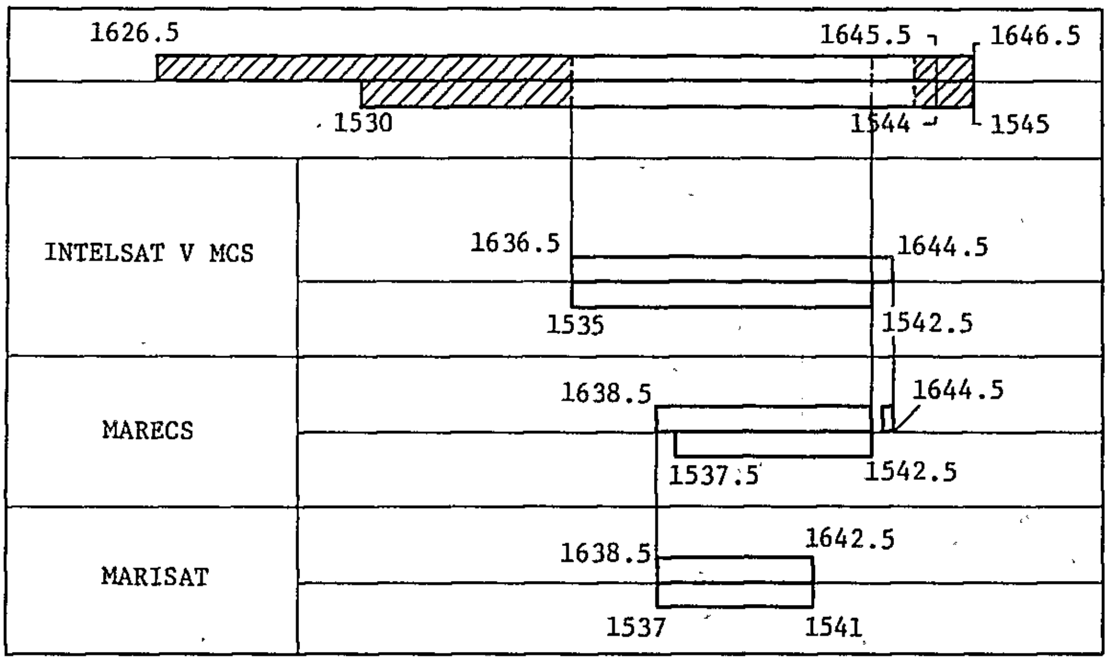


Fig. 5.1.7.5 Statistics of the MARISAT Traffic



: Search and rescue channel

: Additional frequency band allocated at WARC-79

1.6 GHz: Up-Link; 1.5 GHz: Down-Link

Fig. 5.1.7.6 Frequency Band Available for Each Space Segment

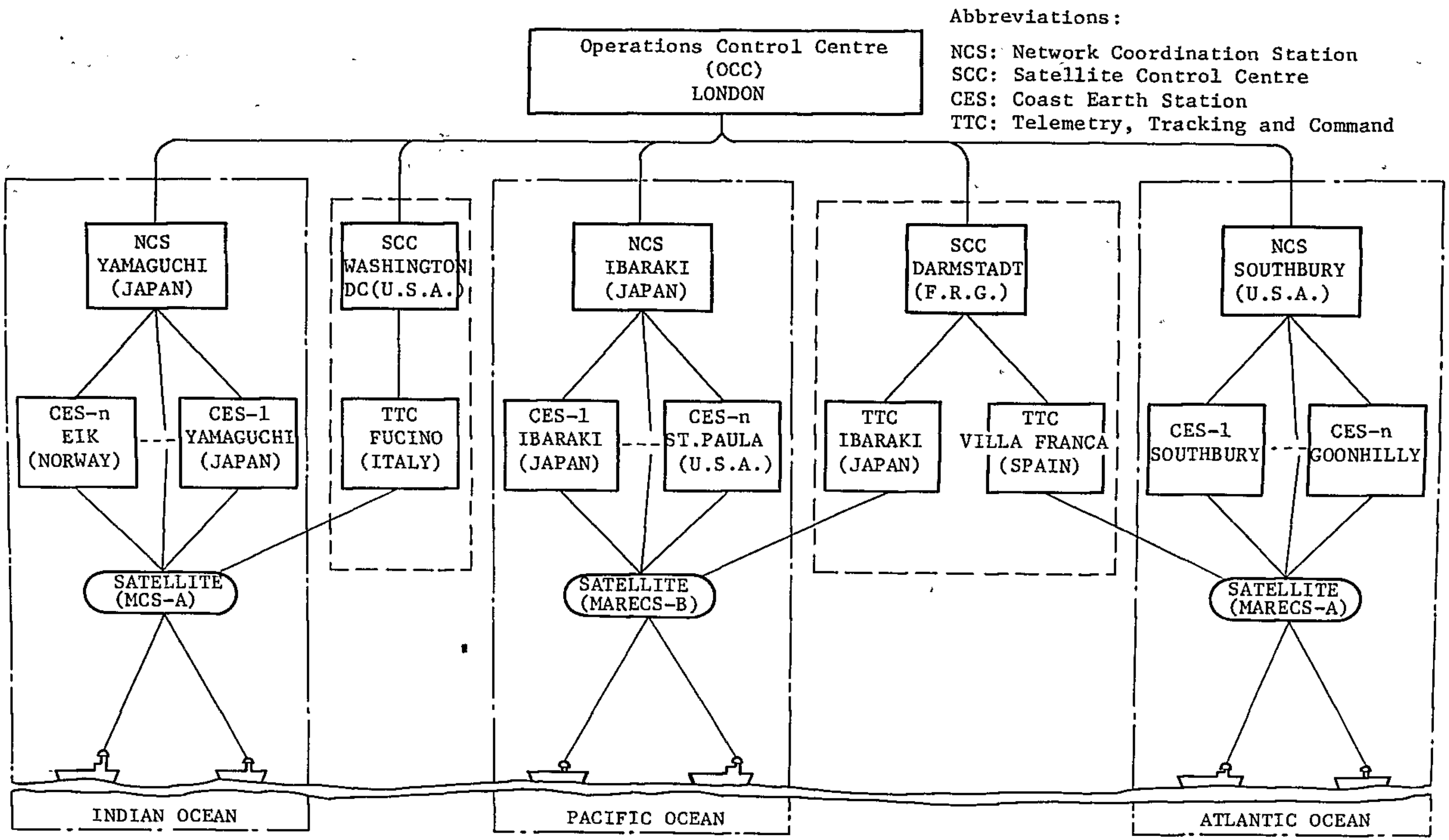


Fig. 5.1.7.7 INMARSAT System Configuration

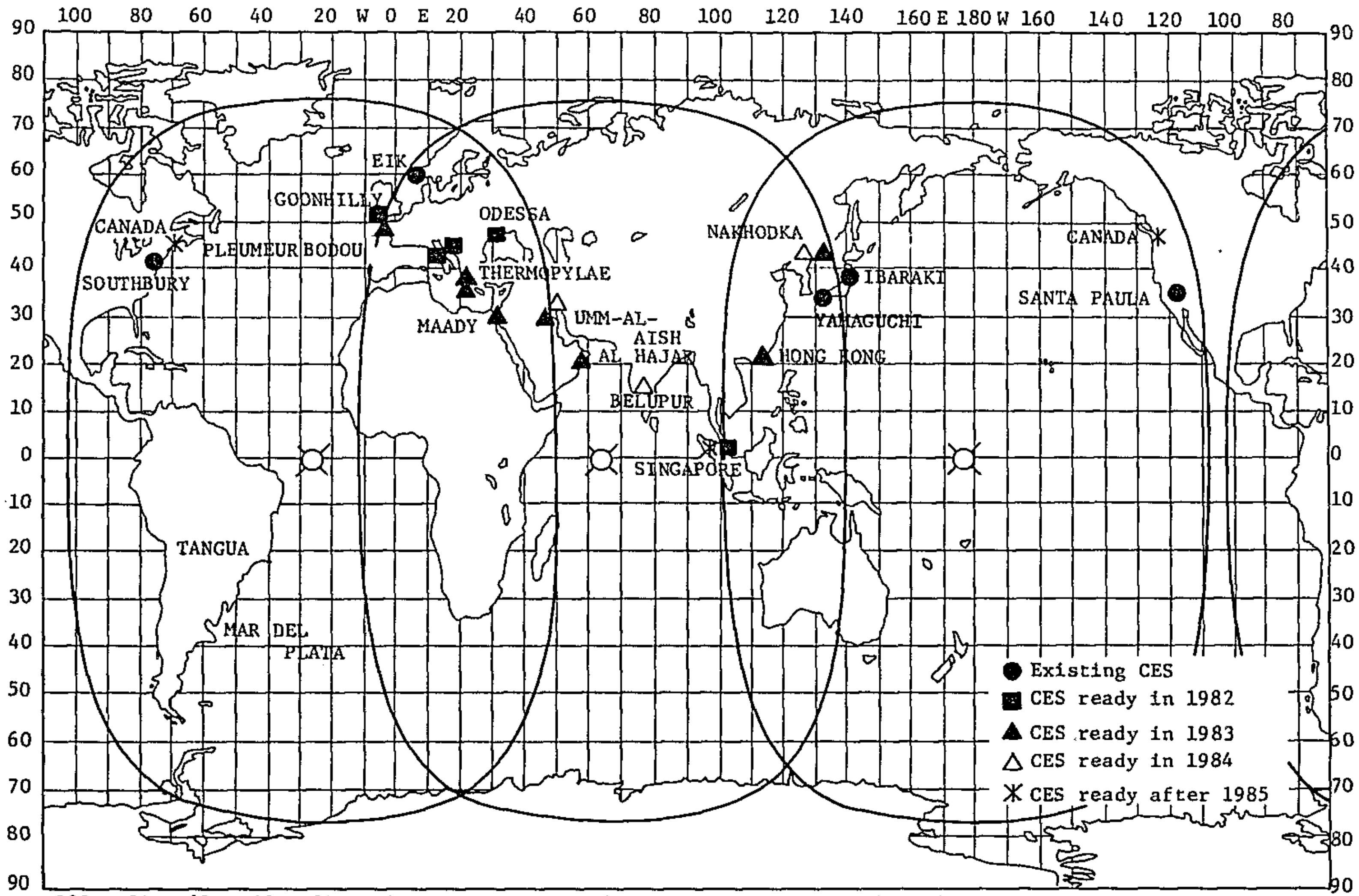


Fig. 5.1.7.8 INMARSAT Satellite Coverage and Coast Earth Station Location

Table 5.1.7.3 Existing and Planned Coast Earth Stations

	Indian Ocean Region			Pacific Ocean Region			Atlantic Ocean Region		
	Country	Location	Completion	Country	Location	Completion	Country	Location	Completion
Existing	Japan	Yamaguchi		Japan	Ibaraki		USA	Southbury	
				USA	Santa Paula		Nordic	Eik**	
1982	Italy	Fucino		Singapore	Singapore*	Oct.	Italy	Fucino*	Dec.
	USSR	Odessa*	Nov.				UK	Goonhilly*	May
							USSR	Odessa*	Nov.
1983	Greece	Thermopylae*		Hong Kong	Hong Kong		France	Pleumeur Bodou*	
	Oman	Al Hajar		USSR	Nakhodka		Kuwait	Umm-Al-Aish*	March
							Argentina	Mar Del Plata	June
							Brazil	Tangua	July
							Egypt	Maady	
							Greece	Thermopylae*	
1984	Kuwait	Umm-Al-Aish							
	USSR	Nakhodka							
	India	Belupur							
1985	Singapore	Singapore							
after 1985				Canada			Canada		

* Under construction

** Switch to IRO from late 1982

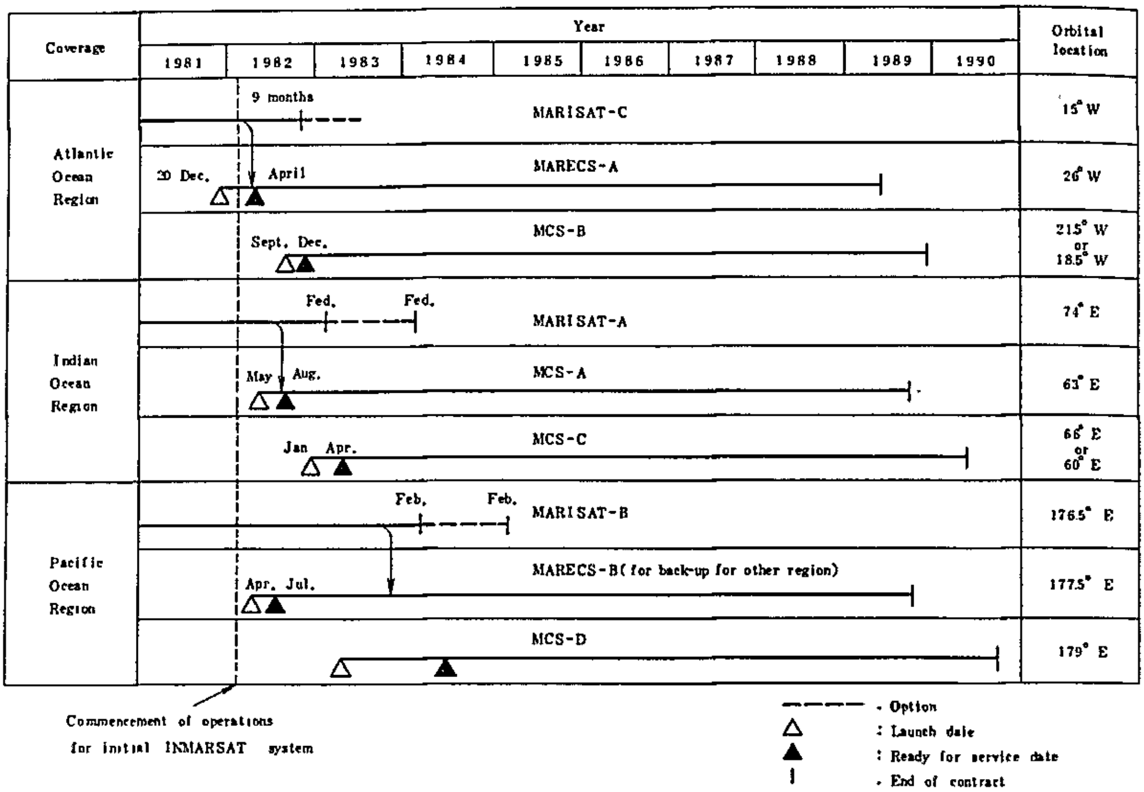


Fig. 5.1.7.9 Operational Plan of INMARSAT System

Table 5.1.7.4 Major Performance Characteristics of INMARSAT Satellites

Satellite	Direction	G/T (dBK)	EIRP (dBW)	Shore-to-Ship Capacity (ch)
INTELSAT V MCS	Ship-to-Shore	-16	17.5 (Saturation)	30 (35)*
	Shore-to-Ship	-21	31.8	
MARECS	Ship-to-Shore	-15	14 (Effective)	40 (50)*
	Shore-to-Ship	-19	33.2	
MARISAT	Ship-to-Shore	-17.5	18 (Saturation)	4 (8)*
	Shore-to-Ship	-22	23	

Note: Listed values in lease contract: ( )*: Expected value

Table 5.1.7.5 Modulation and Multiple Access Method

Channel	Modulation and multiple access	Remarks
Telephone	SCPC-FM	Max. Frequency Deviation: 12 kHz 2:1 syllabic compandor used.
Telegraphy (Ship-to-Shore) (Shore-to-Ship)	 2 ∅ PSK-TDMA 2 ∅ PSK-TDM	 22 bursts per frame: 4,800 bps 22 ch multiplexed: 1,200 bps
High Speed Data (Ship-to-Shore)	4 ∅ PSK	Data rate: 56 kbps; 1/2 convolution code
Reqeust	2 ∅ PSK random access	Burst signal (172 bits): 4,800 bps
Assignment	2 ∅ PSK-TDM	Pre-fixed to telex signal: 1,200 bps

Table 5.1.7.6 Radio Frequency Characteristics of Earth Stations

		Coast Earth Station				Ship Earth Station	
		C-Band		L-Band		L-Band	
		Transmit	Receive	Transmit	Receive	Transmit	Receive
Frequency (MHz)	From	(6410.0)* 6417.5	(4180.0)* 4192.5	(1626.5)* 1636.5	(1530.0)* 1535.5	1636.5	1535.0
	To	6425.5	4200.0	1644.0 (1646.5)*	1542.5 (1545.0)*	1645.0	1543.5
Polarization		RHCP	LHCP	RHCP		RHCP	
Axial Ratio		1.06	(1.06)*	1.3	(1.3)*	2 dB	
Antenna Gain (dBi)		54.0	50.0	29.5	29.0	-	
G/T (dBK)		32.0		2.0		-4.0	
EIRP (dBW)	Request TDM/TDMA	67.0 max.		36.0		36.0	
	Telephone	70.0 max.					
	High Speed Data			38.0		38.0	
	AFC Pilot	59.0 max.		27.0			

( )* --- Recommended value

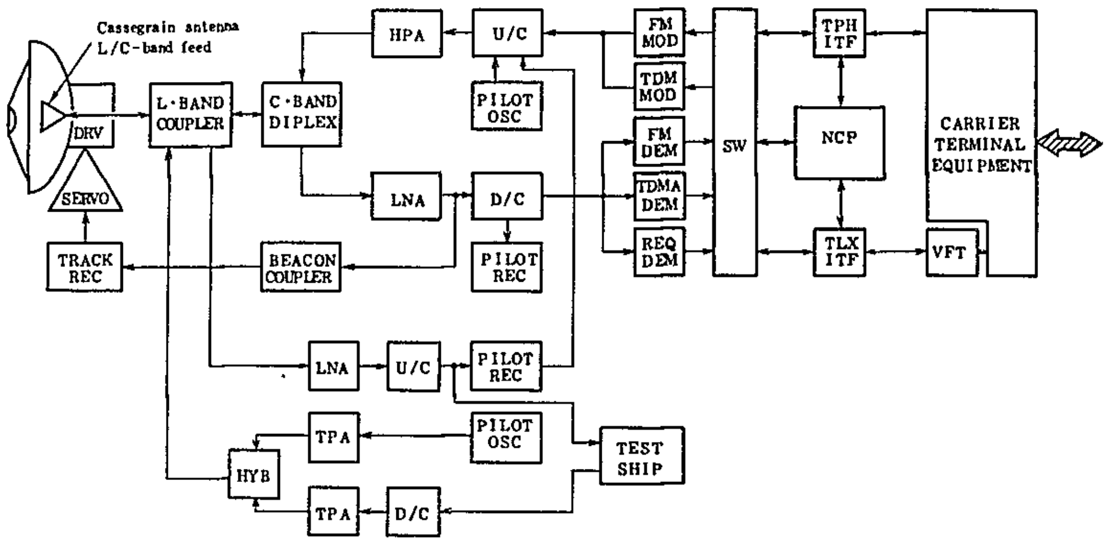


Fig. 5.1.7.10 Block Diagram of Coast Earch Station

Table 5.1.7.7 INMARSAT Ship Earth Stations Standards

Standard		A	B	C	D
G/T (dBK)		-4	-10 to -12	-17 to -19	+5
EIRP (dBW)		36 38 (HSD)	26	19	36 to 46
Antenna	Type (Diameter)	Parabola (0.8 to 1.3m)	Parabola (0.5m) Short Backfire (0.4m) Quad-Helix	Short Backfire (0.3m) Dipole Helix	Parabola (2.5 to 4.0m)
	Gain	20 to 24 dB	15 6o 18 dB	8 to 10 dB	30 to 34 dB
	Beamwidth	10° to 18°	20° to 30°	50° to 65°	3.5° to 5.5°
Service Capability		Telephony Telegraphy Data	Telephony (Low quality) Telegraphy Data	Telegraphy	Multiplexed telephony telegraphy data

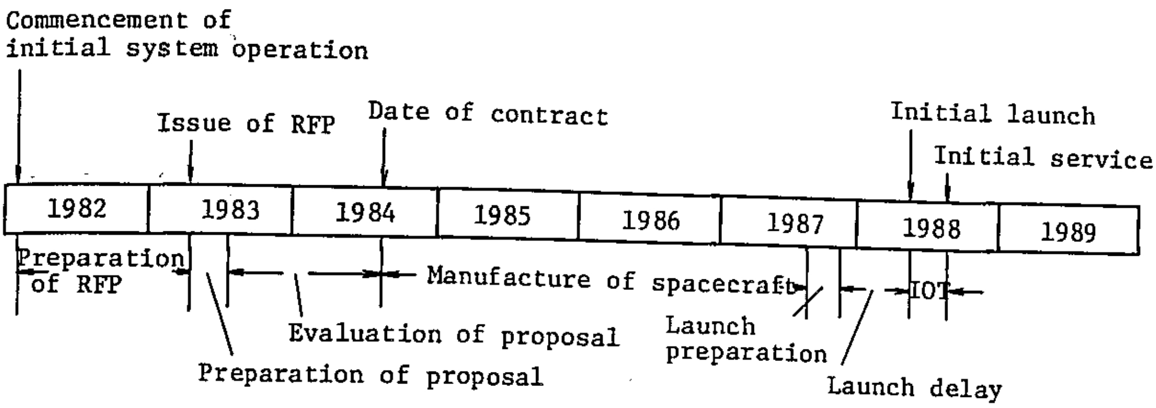


Fig. 5.1.7.11 Procurement Schedule of Second Generation INMARSAT System

Table 5.1.7.8 Summary of INMARSAT R & D Program

INMARSAT R & D Program for the years 1982 - 1986

1. Service Aspects
   1.1 Traffic Forecast
   1.2 Future INMARSAT Services
2. Studies Specifically Related to Distress and Safety
3. Low G/T Ship Earth Stations
4. Standard D Ship Earth Stations
5. Satellite Concepts
   5.1 Satellite System Configuration
   5.2 Satellite Technologies
6. Efficient Utilization of Bandwidth and Satellite Power
7. One Way Transmissions (Broadcast)
8. Polling
9. Operational Aspects
10. Propagation

R & D Subjects to be contracted out in 1982

1.	Standard C and Standard D System Studies	1
2.	Definition of Characteristics of Basic Spacecraft Models	2
3.	Satellite Technologies	2
4.	Future Global Distress System	4
5.	Design of a System for Ship Position Determination By Ranging through INMARSAT Satellite	6
6.	Measurement of Performance of Standard A SES Operating at Very Low Elevation Angles	5
7.	Voice Coding Techniques for Standard A and Standard B Ship Earth Stations	3
8.	Digital Transmission Systems	*

*: Added at the 10th Council Session

5.1.8 Development Trends in Optical-fiber Submarine Cable Systems

An optical fiber transmission system using a low-loss and wide-band optical fiber was developed in 1970. At the end of the 1970s, optical fibers with low losses near the theoretical value were developed with an optical loss of 0.4 dB/km at a 1.3-μm wavelength and 0.2 dB/km at 1.55-μm.

Research into optical-fiber submarine cable systems started in the mid-1970s by various research laboratories around the world. Ocean tests have started to be made successively beginning in 1980. An intermediate distance system is scheduled to be installed for commercial application in 1985, and a long-haul system, around 1988. Fig. 5.1.8 (1) shows the development status of optical-fiber submarine cable systems by various countries.

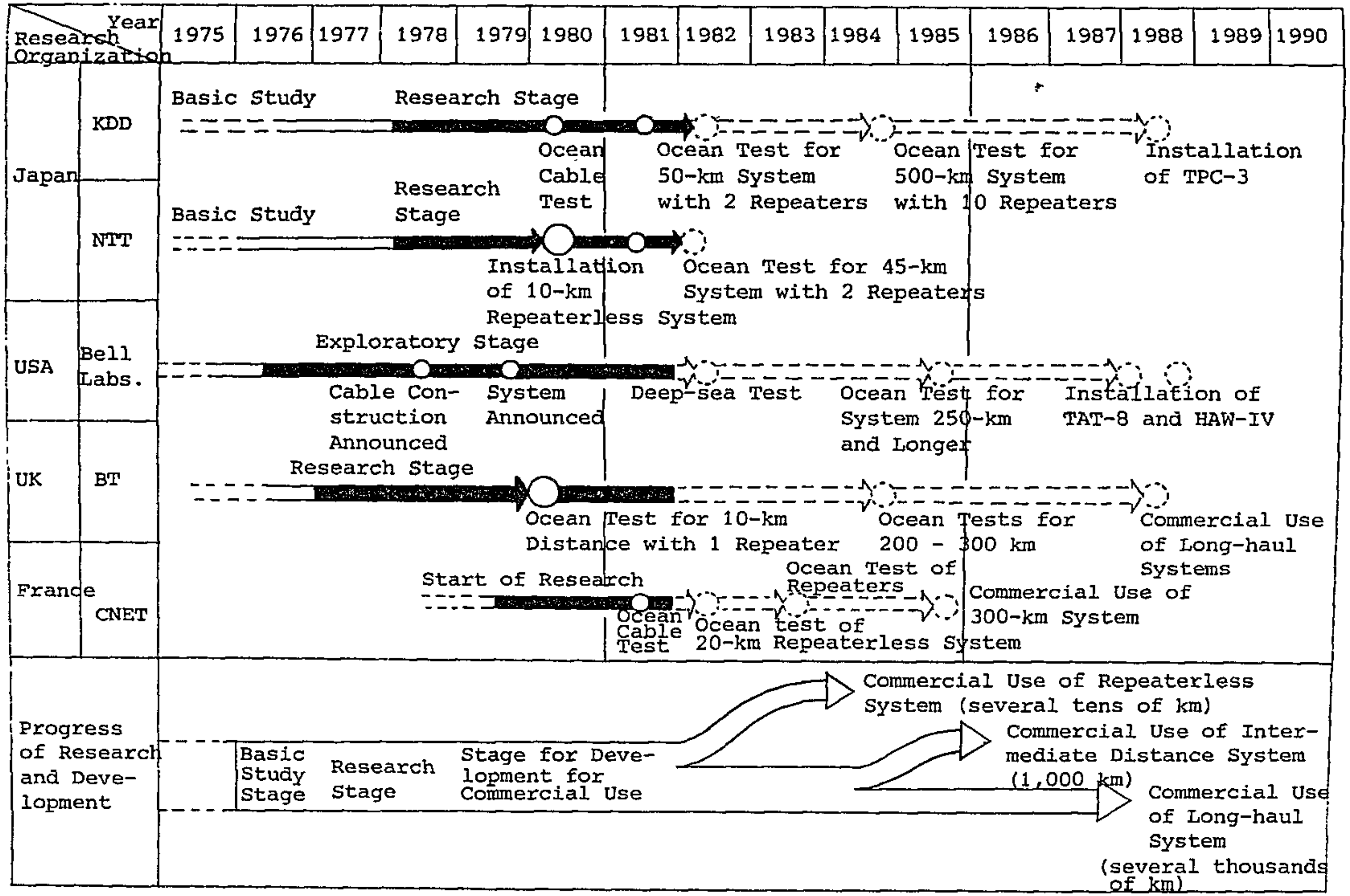


Fig. 5.1.8.1 Research and Development of Optical-Fiber Submarine Cable Systems

(1) Optical-Fiber Submarine Cable System

Table 5.1.8.2 shows design goal specifications for optical-fiber submarine cable systems being developed by various countries.

Except for NTT, which requires short-haul, large volume transmission for domestic traffic, these countries are developing systems centered on a digital transmission speed of approximately 300 Mbps.

The number of subsystems varies between 1 and 5. In the interests of economy and reliability, 1 to approximately 3 subsystems are considered desirable.

Regarding the optical wavelength, 1.3 μm has been selected because of a relatively low loss and zero dispersion of single-mode optical fiber at this wavelength. The wavelength of 1.55 μm is desirable particularly for a long-haul system (7500 to 10,000 km) because the optical-fiber transmission loss is the smallest at this wavelength. However, the question of high reliability of a semiconductor laser for this wavelength has to be solved, and 1.55 μm wavelength is considered as a wavelength for the next-generation of optical-fiber submarine cable systems.

Repeater spacing has a design goal allowing a margin in the entire cable system because of still uncertain factors in characteristics of the laser diode, optical fiber, and photodetector. However, judging from the development of optical fibers with low optical losses, repeater spacings of approximately 50 km in 1.3 μm transmission seem possible.

Table 5.1.8.2 Optical-Fiber Submarine Cable Systems Under Development by Various Countries

Specifications \ Country	Japan KDD	Japan NTT	USA Bell Labs.	UK British Telecom	France CNET
Transmission Bit Rate	- 280Mb/s	400Mb/s	>274Mb/s	(140). 280Mb/s	(140). 280Mb/s
Number of Subsystems	1 - 3	1 - 2	1 - 3	1 - 5	1 - 4
Number of Optical Fibers	2 - 6	2 - 4	2 - 6	2 - 10	2 - 8
Maximum System Length	10,000km	1,000km	8,000km	7,500km	10,000km
Maximum Depth of Water	8,000m	8,000m	7,500m	7,500m	>6,500m
Repeater Spacing	30 - 50km	25km and over	30 - 35km	25 - 50km	25 - 50km
Optical Wave Length	1.3µm	1.3µm	1.3µm	1.3µm	1.3µm
Optical Fiber	SMF	SMF	SMF	SMF	SMF
Repeater Fault Locating Method	Optical loop-back	Under study	Electric loop-back	Electric loop-back	Loop-back
System Life	25 years	20 years and over	24 years	25 years	25 years
Reliability	MTBF 10 years	—	MTBF 8 years	MTBF 10 years	MTBF 15 years

As a photodetector, InGaAsP has an excellent characteristic in the long wavelength region of 1.3 to 1.6 µm. A Ge APD has already been developed as a photodetector in the long wavelength region. An InGaAs photodetector with an improved noise characteristic is being developed.

(2) Optical-Fiber Submarine Cable

Various materials and constructions are being studied regarding the cable construction with the following items as goals:

① Small transmission loss increase
② Stable construction with good manufacturability
③ Prevention of the intrusion of seawater into the cable when the cable is cut
④ Elongation relaxation effect on optical fibers
⑤ Resistance to high water pressure in water depths of 6500 to 8000 m
⑥ Resistance to tensions of 8 to 9 tons

Fig. 5.1.8.2 shows optical-fiber cable constructions being developed by various countries. Thus viewed, various proposals have been made regarding optical-fiber cable construction, and it is difficult to determine which construction is most desirable.

The optical-fiber cable construction is an important matter in realizing an optical-fiber submarine cable system, and further improvements are expected to be made in the future.

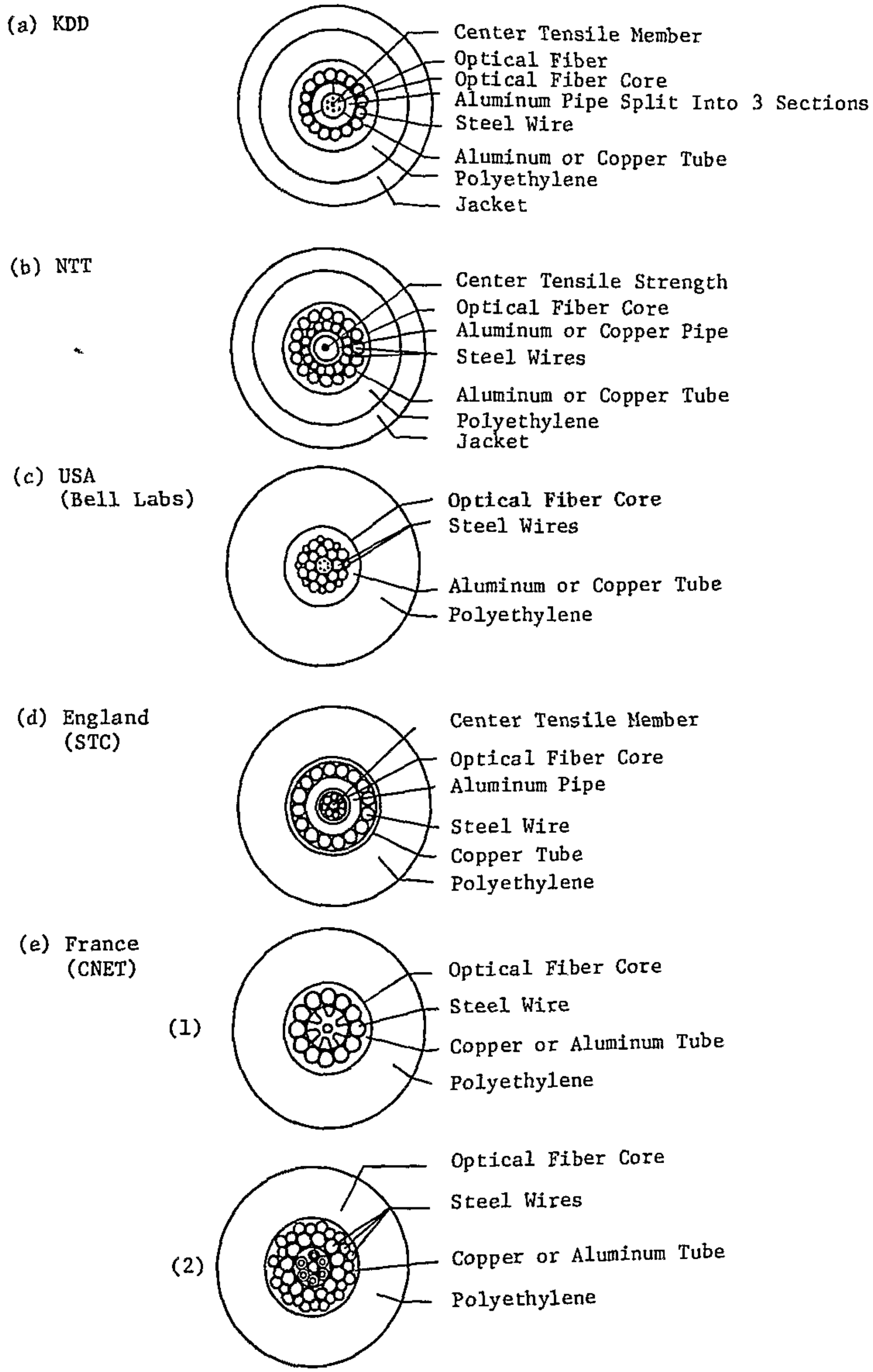


Fig. 5.1.8.2 Sectional Views of Optical-fiber Submarine Cables Developed by Various Countries