4. DEMAND FORECAST AND TRAFFIC FORECAST

4. Demand Forecast and Traffic Forecast

4-1. Telecommunication Network Plan for Sulawesi Area

PERUMTEL has nearly completed formulation of its REPELITA IV for telecommunication network improvement to begin in 1984. This plan constitutes an integral part of REPELITA IV of the Government of Indonesia.

The REPELITA IV period is an extremely important period for the promotion of Long Term Plan by the Year 2000. According to the REPELITA IV (draft) obtained in the course of Feasibility Study, this time, the REPELITA IV is aimed at positive introduction of digital switching equipment and digital transmission system for the purpose of qualitative improvement of telecommunication services. At the same time, the REPELITA IV is intended for broad telephone diffusion by means of increased installation of switching equipment on a large scale.

The telecommunication network improvement plan for Sulawesi area, the objective area of Feasibility Study, this time, includes part of the REPELITA IV, so that these two plans are inseparably interrelated. Therefore, both demand forecast and traffic forecast are made, starting with the REPELITA IV (draft).

(1). Telephone

a) The REPELITA IV (draft) seeks broad expansion of main telephone density by means of 2.3 times increase of local switches during the plan period. In other words, when the REPELITA IV is accomplished, the telephone density per 100 population, which presently is 0.27, will improve to an estimated 0.90. Nevertheless, such telephone density is not high enough when compared with the main telephone density among ASEAN countries. On the contrary, for the Republic of Indonesia as an ASEAN group leader with rich national resources, such telephone density is rather too low.

However, the main telephone density is not the sole means of telecommunication service evaluation. Needless to say, speech quality and connection performance are no less important yardsticks to telephone service evaluation. When the REPELITA IV is realized, a large number of old-fashioned switching equipment installed and operating in main cities will have been replaced with new digital switching equipment. This, in turn, will step up SLDD and transmission route digitalization. By this means, Indonesia can realize high quality telecommunication network which it can boast of to its neighbor countries.

b) In Sulawesi area, where this Project is to be implemented, the main telephone density per 100 population is 0.21 as of June 1982. When the REPELITA IV is accomplished, this density will improve to approximately 0.60. In this case also, the main telephone density by simple calculation proves to be lower than the national average in Indonesia.

Assume that the REPELITA IV will make progress as schedules and the trans-Sulawesi digital terrestrial transmission route, one of Feasibility Study items, this time, will be realized as planned. Then, Sulawesi will become the high quality telecommunication network area that deserves to be called "Digital Island". As the result, no small part of latent demand will be actualized, leading to quantitative, as well as qualitative, expansion and improvement of telephone service in Sulawesi area.

Further details of increased local switch installation and automatic telephone service program for Sulawesi area by the REPELITA IV (draft) are given in ANNEX 2.

(2) Telex

a) During 1977 through 1981, telex terminals in all parts of Indonesia increased at a high rate of 29% in annual average. The REPELITA IV (draft) assumes that such high rate increase of telex terminals can no longer be expected from now forward, and that the growth rate during the plan period will not be greater than 15% annually.

b) The REPELITA IV (draft) does not specifically refer to telex service demand in Sulawesi area. It refers to non-telephone service network as a whole, presenting a plan to increase line capacity from existing 650 to 1,300 lines.

This line capacity increase is not to fill demand in Sulawesi area only, but to cater for demand in Jayapura, Sorong and Ambon areas outside of Sulawesi also. This arrangement is because Ujung Pandang is a tandem exchange in non-telephone service network.

4-2. Demand Forecast for Telecommunication Services

4-2-1 Telephone Service

(1) Macroscopic Demand Forecast

a) To forecast the future main telephone density from correlations between main telephone density and GDP is effective for macroscopic forecast of national capability. Geographical and economic conditions of Sulawesi area are such that, for telephone demand forecast, the whole area can be considered as an independent state, so that this assumption used here as one method of macroscopic forecast.

Correlations between main telephone density and GDP in 31 countries of the world are graphically presented in ANNEX-2. Correlation formula obtained by regression analysis follows:

$$Y = 0.000136 \cdot X^{1.37}$$

(Correlation coefficient: 0.87)

where

Y : Main telephone density (per 100 population)

X : GDP per capita (in U.S. dollars, in constant price as of 1979)

b) Another method of macroscopic telephone demand forecast is to forecast the future main telephone density by means of time series analysis of main telephone density variations. Growth trends of main telephone density in the entire Indonesia and in Sulawesi area during the past five years appear in Table 4-1.

Regression formula obtained from main telephone density variation in Sulawesi area, i.e., the past growth plus growth by the REPELITA IV (draft), follows:

$$Y = 0.1218 \cdot e^{0.096X}$$

(Correlation coefficient: 0.94)

where

Y : Main telephone density (per 100 population)

X : Integer for each year after 1977 (1977: 1)

e : Natural logarithm (= 2.71828)

c) Result of telephone demand forecast for Sulawesi area by the foregoing two methods of macroscopic forecast appears in Table 4-2.

(2) Microscopic Telephone Demand Forecast

a) Forecast Area and Forecast Bloc

The objective area of Feasibility Study, this time coincides with Ujung Pandang Tertiary Center area in the telephone network. The transmission route taken up for scrutiny in this Feasibility Study is the toll transmission route that connects Primary and higher ranking centers in network hierarchy. Therefore, it is reasonable to determine Primary Center area as demand forecast bloc. However, for demand forecast by Primary Center area, study for each local exchange in the area is necessary.

b) Forecast Method

The Master Plan and the REPELITA IV (draft) are used as basic data. These data are checked and corrected, where necessary, based on findings in this Feasibility Study. Then, forecast is made for the required line capacity at each local exchange in the forecast year concerned.

90% of line capacity thus obtained is used as the forecasted number of subscribers in each forecast year.

c) Result of Forecast

Result of microscopic telephone demand forecast by Primary Center area appears in Table 4-3. Study result for each local exchange is given in ANNEX 2.

(3) Study of Forecast Result

a) Results of macroscopic and microscopic telephone demand forecasts for Sulawesi area are shown in Table 4-4.

Table 4-4 Subscriber Forecast Results

Year	Macro-Forecast by GDP (10^3)	Macro-Forecast by Time Series Analysis (10^3)	Micro-Forecast (10^3)
1994	81	97	97
1999	124	174	136
2005	213	353	203

b) As seen in Table 4-4, result of forecast varies more or less, depending upon the method of forecast. For Sulawesi area telephone demand forecast, if the macroscopic forecast result is to be used intact, the degree of error inherent in the macroscopic forecast method itself must be allowed for. When the difference between macroscopic and microscopic forecast results is properly distributed among Primary Center areas, digital transmission route capacity is not seriously affected. Demand forecast in this Study is to determine transmission system capacity, wherein Primary and higher ranking centers are connected, and to select digital transmission system. Hence, for telephone demand forecast value, the microscopic forecast result is used.

4-2-2 Non-Telephone Services

(1) Telex

Uptrend of demand for telex service in recent years is evident in Table 4-5.

Table 4-5 Growth of Telex Terminals in Indonesia

Year	No. of Terminals	Growth Rate (%)
1977	2,397	33.5
1978	3,200	25.3
1979	4,009	31.9
1980	5,289	26.2
1981	6,679	-

(Source: REPUMTEL's "Annual Report 1981")

In the REPELITA IV (draft), 15% telex terminal growth is to be achieved during the plan period of 1984 - 1989.

Demand for telex service slows down as telephone diffusion progresses, as is proven in many foreign countries. However, considering that more than 60% of telex terminals are concentrated in Jakarta whereas in Sulawesi area, as in several other areas, regional development is to be stepped up from now forward, the slowdown of telex demand growth will be mild. Furthermore, part of demand for telex service will, as a matter of course, transfer to new services, such as facsimile service.

In this Study, the growth rate of demand for telex service in Sulawesi area is estimated at 12% annually during 1989 - 1994, 9% annually during 1995 - 1999 and 6% annualy during 2000 - 2005.

(2) Telegraph

The number of telegram messages handled in Indonesia is on upgrade. Growth trends in recent four years are shown in Table 4-6.

Table 4-6 Growth Trend of Telegram Message in Indonesia

Year	No. of Telegram Messages (10^3)	Growth Rate (%)
1977	4,403	11.4
1978	4,905	12.2
1979	5,503	17.2
1980	6,452	-

Delay of telephone diffusion compared with population increase and economic growth progress is one of reasons for high annual growth of telegraph service. However, as additional telephone installations by the REPELITA IV pull up momentum, the growth trend of demand for telegraph service will slow down. In due time, demand growth will terminate and downgrade of demand will begin. This is a foregone conclusion that is exemplified by the state of affairs in developed countries.

In the Master Plan, forecast is made for annual downgrade of telegraph demand growth rate with the saturation point for demand seen around 1999. In this Study, such Master Plan forecast is adopted.

(3) New Services

For new services, such as facsimile service and data communication service, concrete records or definite plan for the future are not available. As of the present, demand forecast is extremely difficult.

However, demand for new services may possibly build among government and public offices and big private enterprises. These major users will become equipped with their leased circuits for new services. Others may gain access to new services via public telecommunication network.

Taking such possibilities into consideration, assumption is made in this Study to the effect that in 1989 and after, demand for new services, including transfer from telex demand, will continue 20% per year growth.

(4) Demand forecast results for telex, telegraph and new services appear in Table 4-7.

Table 4-1 Telephone Demand and Telephone Density (1977~1981)

Area	Item \ Year	1977	1978	1979	1980	1981	Remarks
Whole Indonesia	Population ($x10^6$)	133.94	136.63	139.38	142.18	145.04	
	No. of Telephone ($x10^3$)	347.0	392.6	441.3	512.9	564.5	
	Telephone Density / 100 Inhabit.	0.259	0.287	0.317	0.361	0.389	
	No. of Main Telephone ($x10^3$)	239.3	275.1	317.1	369.8	416.7	
	Main Telephone Density / 100 Inhabit.	0.179	0.201	0.228	0.260	0.287	
Sulawesi Area	Population ($x10^6$)	9.75	9;96	10.18	10.41	10.64	
	No. of Main Telephone ($x10^3$)	14.4	15.2	15.9	16.6	19.9	
	Main Telephone Density / 100 Inhabit.	0.148	0.153	0.156	0.159	0.187	

Source : (1) Annual Report 1981, POSTEL

(2) Data of Telephone Facilities, WITEL-X

(3) PRANSEN

Table 4-2 Macroscopic Telephone Demand Forecast in Sulawesi Area

Item	Year	1979	1980	1981	1982	1984	1989	1994	1999	2005
Population: 10^3 (Ave. Annual Growth Rate: %)		10,185.4 (2.2)	10,409.5 (2.2)	10,638.5 (2.2)	10,872.6 (2.2)	11,356.2 (2.2)	12,661.6 (2.2)	14,117.0 (2.2)	15,739.8 (2.2)	17,935.1 (-)
GDP per capita: US$ in 1979: 10^6 (Ave. Annual Growth Rate: %)		[340x0.9] 306 (6.0)	324 (6.0)	343 (6.0)	364 (6.0)	409 (5.0)	522 (5.0)	666 (5.0)	850 (5.0)	1,139 (-)
Demand Forecast by GDP per Capita	Main Telephone Density (per 100 inhabit.)	0.16	0.16	0.19	0.21	0.29	0.41	0.57	0.79	1.19
	No. of Main Telephones: 10^3	15.9	16.6	19.9	23.0	32.9	51.9	80.5	124.3	213.4
Demand Forecast by Historical data	Main Telephone Density (per 100 inhabit.)	0.16	0.16	0.19	0.21	0.26	0.42	0.69	1.11	1.19
	No. of Main Telephones: 10^3	15.9	16.6	19.9	23.0	29.5	53.2	97.4	174.7	353.3

← Statistic → | ← Forecast →

Table 4-3 Microscopic Telephone Demand Forecast 1/2

Code No.	Primary Area	Line Capacities			Distribution Ratio for Terrestrial Link (%)	
		1994	1999	2005		
411	Ujung Pandang	47,200	60,000	90,000	-	-
412	Watampone	1,200	1,400	1,800	80	
413	Bantaeng	2,300	3,600	5,400	80	To Ujung Pandang
414	Benteng	(400)	1,000	1,800	80	
415	Tanahjampea	(100)	(200)	500	80	
Sub Total		51,200	66,200	99,500		
421	Pare Pare	7,950	13,000	19,500	100	To Ujung Pandang
422	Majene	(450)	1,000	1,700	80	To Pare Pare
423	Rantepao	(450)	800	1,200	80	
424	Palopo	1,300	1,600	1,900	80	
425	Sengkang	600	800	1,200	80	
426	Mamuju	(400)	800	1,200	80	
427	Masamba	(200)	(300)	500	80	
428	Malili	(200)	(300)	500	80	
429	Karosa	(200)	(300)	500	80	
Sub Total		11,750	18,900	28,200		
431	Manado	17,000	28,000	42,000	40	To Ujung Pandang
432	Tahuna	(300)	(400)	500	0	To Manado
433	Beo	(100)	(200)	500	0	
434	Kotamobagu	800	1,100	1,700	80	
435	Gorontalo	5,000	8,000	12,000	80	
436	Tilamuta	(200)	(300)	500	80	
437	Paleleh	(200)	(300)	500	0	
Sub Total		23,600	38,300	57,700		

Note; ( ) : Manual Primary Center

Table 4-3 Microscopic Telephone Demand Forecast 2/2

Code No.	Primary Area	Line Capacities			Distribution Ratio for Terrestrial Link (%)	
		1994	1999	2005		
451	Palu	7,100	8,800	14,700	80	To Ujung Pandang
452	Poso	3,600	4,500	5,400	80	To Palu
453	Toli Toli	1,600	2,500	3,250	80	
454	Uekuli	(100)	(200)	800	80	
455	Kolonedale	(100)	(200)	500	80	
456	Bungku	(100)	(200)	500	80	
457	Unauna	(100)	(200)	(300)	0	
458	Luwuk	2,700	3,700	4,700	80	
459	Banggai	(100)	(200)	500	80	
Sub Total		15,500	20,500	30,650		
401	Kendari	4,000	5,000	6,000	80	To Ujung Pandang
402	Baubau	(400)	600	900	80	To Kendari
403	Raha	(300)	400	500	80	
404	Papalia	(100)	(200)	(300)	0	
405	Kolaka	(300)	600	900	80	
406	Malamala	(100)	(200)	500	80	
407	Unaaha	(300)	500	800	80	
Sub Total		5,500	7,500	9,900		
Grand Total		107,550	151,400	225,950		

Note; ( ) : Manual Primary Center

Table 4-7 Demand Forecast for Non-Telephone Services

Service	Area	1980	1989	1994	1999	2005
Telex Lines	Ujung Pandang (Sulawesi Selatan)	75	331	585	898	1,277
	Kendari (Sulawesi Tenggara)	6	28	49	75	106
	Palu (Sulawesi Tengah)	28	124	220	337	479
	Manado (Sulawesi Utara)	47	207	366	560	798
	Total	156	690	1,220	1,870	2,660
	Growth Rate/Year	18%	12%	9%	6%	
	Whole INDONESIA	5,289	23,460	41,340	55,330	66,060
	Growth Rate/Year	18%	12%	6%	3%	
New Service Subscribers	Ujung Pandang (Sulawesi Selatan)	-	15	45	105	308
	Kendari (Sulawesi Tenggara)	-	2	4	11	33
	Palu (Sulawesi Tengah)	-	3	6	15	45
	Manado (Sulawesi Utara)	-	10	25	59	174
	Total	-	30	80	190	560
	Growth Rate/Year	-	20%	20%	20%	
	Whole INDONECIA	*200	1,030	2,570	6,390	19,080
	Growth Rate/Year	20%	20%	20%	20%	
Telegram Messages per Year (x 10^3)	Ujung Pandang (Sulawesi Selatan)	373	879	1,122	1,301	1,301
	Kendari (Sulawesi Tanggara)	58	137	175	202	202
	Palu (Sulawesi Tengah)	149	352	449	521	521
	Manado (Sulawesi Utara)	249	587	749	868	868
	Total	829	1,955	2,495	2,892	2,892
	Growth Rate/Year	10%	5%	3%	0%	
	Whole INDONEDIA	6,452	15,213	19,416	22,508	22,508
	Growth Rate/Year	10%	5%	3%	0%	

* : Estimated by Master Plan

Source: (1) Annual Report 1981
(2) Data by WITEL-X

4-3. Traffic Forecast

4-3-1 Forecast of SLDD Calling Rate

(1) Toll Traffic Status and Analysis

a) Using data obtained in this Study, estimate was made for SLDD calling rates at Ujung Pandang Exchange and Manado Exchange. Calculation procedures and data used are shown in ANNEX-2. Results are shown in Table 4-8.

Table 4-8 Present SLDD Calling Rate

Exchange	SLDD Calling Rate
Ujung Pandang	0.0050 Erl.
Manado	0.0063 Erl.

b) According to data obtained at Manado Exchange and survey result, this time, one-month total of call meterings among part of Manado Exchange subscribers exceeds 100,000. Subscribers, whose one-month total of call meterings does not reach 100,000 but is close to 100,000, are not few. This fact presumably reflects the low main telephone density plus numerosity of calls to Jakarta, the distant destination from Manado.

SLDD calling rate estimate in the preceding paragraph is based on Manado Exchange call metering data (see ANNEX 2.). This can be considered to be the reason why the calculated calling rate is extremely high.

(2) Originating Calling Rate Forecast

The higher the main telephone density, the lower the originating calling rate per subscriber. Correlation data between local area size and SLDD calling rate can be found in CCITT Manual also.

For SLDD calling rate forecast in Sulawesi area, the existing records only are not sufficient. CCITT data (*) are also taken into consideration in the SLDD calling rates forecast. Results are shown in Table 4-9.

Table 4-9 SLDD Originating Calling Rates

Local Area Size (No. of Subscribers)	SLDD Calling Rate (Erl.)
- 300	0.009
301 - 500	0.008
501 - 1,000	0.007
1,001 - 4,000	0.006
4,001 - 7,000	0.005
7,001 -	0.004

(*): The list of CCITT data used follows:

- Seminar on the Planning and Development of Telecommunication Networks Outside of Large Cities and the Maintenance of Telecommunication Services (ITU: In Kuala Lumpur, February 21 - March 3, 1972)
- Local Network Planning (ITU: Geneva, 1979)

- A Telephone Development Project
(Stockholm, April 1965)

4-3-2 Toll Traffic Calculation

(1) Basic Traffic

Formula whereby to calculate toll traffic is as follows:

$A_{LD} = N \cdot C_R$ (Erl.)

where

A_{LD}: Toll originating traffic of local exchange

N : Number of subscribers

C_R : SLDD originating calling rate

$A_T = \sum A_{LD}$ (Erl.)

where

A_T : Toll originating traffic in Primary Center area

Table 4-10 presents the result of calculation (A_T) of toll originating traffic of local exchanges (A_{LD}) in each Primary Center area. This traffic volume is used as basic traffic whereby to determine transmission system capacity.

(2) Traffic Distribution Philosophy

a) Gravity model formula given in CCITT GAS-5 Manual is a method to obtain section by section toll traffic distribution ratio. This method is based on the fact that traffic between two exchanges is directly proportional to the number of subscribers accommodated in each exchange and is inversely proportional to the distance between two exchanges.

Gravity model formula follows:

$$R_{ij} = \frac{\dfrac{Si}{D^{\alpha}_{ij}}}{\dfrac{S^1}{D^{\alpha}_{ij}} + \dfrac{S^2}{D^{\alpha}_{ij}} + \ldots\ldots + \dfrac{S^j}{D^{\alpha}_{ij}} + \ldots\ldots + \dfrac{S^n}{D^{\alpha}_{ij}}}$$

where

- i : Exchange where traffic forecast is made
- j : Distant exchange
- R_{ij}: Traffic distribution ratio between i and j
- S : Number of subscribers
- D : Distance between exchanges
- α : Coefficient whereby to convert distance between exchanges to social/economic distance

b) In the calculation of traffic distribution ratio by the gravity model formula, the following points are duly considered:

- Distance on the map between Sulawesi area and Jakarta is extremely long. Nevertheless, the social/economic distance is overwhelmingly short, compared with the corresponding mutual distance among cities in Sulawesi area.

- For example, according to the result of analysis of existing traffic interflow (see ANNEX 2), more than 80% of toll originating traffic of Ujung Pandang Exchange is to destinations outside of Sulawesi area. Same is the case with Manado Exchange also.

- However, originating traffic from Pare Pare area is associated with Ujung Pandang area to a relatively large degree.

- With regard to the foregoing traffic distribution characteristics, no major change is expected to arise from now forward.

(3) Traffic Distribution

a) Toll originating basic traffic (A_T) is distributed in the following manner:

- As traffic to outside of Sulawesi area

- As traffic to other Secondary Center area in Sulawesi area

- As traffic to area of Secondary Center to which Primary Center concerned belongs

b) Traffic distribution mentioned in the preceding paragraph is made, based on status quo of traffic interflow in existing network (see ANNEX 2) and ITU's "Local Network Planning (Geneva, 1979)", by the distribution ratios appearing in Table 4-11.

Table 4-11 Traffic Distribution Ratios (%)

Originating from	Outside of Sulawesi Area	Inside of Sulawesi Area: Own Secondary Center Area	Inside of Sulawesi Area: Other Secondary Center Area
Ujung Pandang, Manado, Palu, Kendari areas	80	10	10
Pare Pare area	70	10	20

c) Results of distribution by directions of toll originating basic traffic as per the preceding paragraphs are further distributed by destinations, using gravity model formula. By this means, section by section traffic volume is determined.
The volumes of section by section traffic are shown in ANNEX (Figure AN-7).

4-3-3 Traffic Distribution between Terrestrial Transmission Link and Satellite Link

(1) Distribution Planning

For traffic distribution between terrestrial transmission link and satellite link, calculation is made by the distribution ratios given by PERUMTEL. The ratios appear in the table below.

Table 4-12 Traffic Distribution Ratios

Crow-Flight Distance of Transmission Section X (km)	Terrestrial Link (%)	Satellite Link (%)
$X < 500$	80	20
$X \geq 500$	40	60

(2) Inter-Exchange traffic Calculation

Inter-exchange traffic calculated in the preceding paragraph 4-3-2 is concentrated according to toll network cofiguration. Then, by the distribution ratio in Table 4-12, traffic to be carried by terrestrial transmission link is calculated. Calculation results appear in Figure 4-1.

4-3-4 Calculation of Non-Telephone Service Traffic

For busy hour originating traffic relating to non-telephone services in Sulawesi area, calculation is made by formulas shown below. Calculation results appear in Table 4-13.

(1) Telegraph Traffic

$$A_{tg} = M \cdot C_1 \cdot C_2 H / 3,600$$

where

- A_{tg}: Telegraph traffic (Erl.)
- M : Number of telegram messages per year
- C_1 : Coefficient whereby to convert M to number of telegram messages per weekday (1/300)
- C_2 : Coefficient whereby to convert M to busy hour number of telegram messages (1/8)
- H : Average holding time per telegram message (125 sec.)

(2) Telex Traffic

$$A_{tx} = N \cdot C_r$$

where

- A_{tx}: Telex traffic (Erl.)
- N : Number of telex terminals
- C_r : Originating calling rate per terminal (0.05)

(3) New Service Traffic

$$A_{dt} = N \cdot C_r$$

where

A_{dt}: New service traffic (Erl.)

N : Number of new service subscribers

C_r : Originating calling rate per subscriber (0.1)

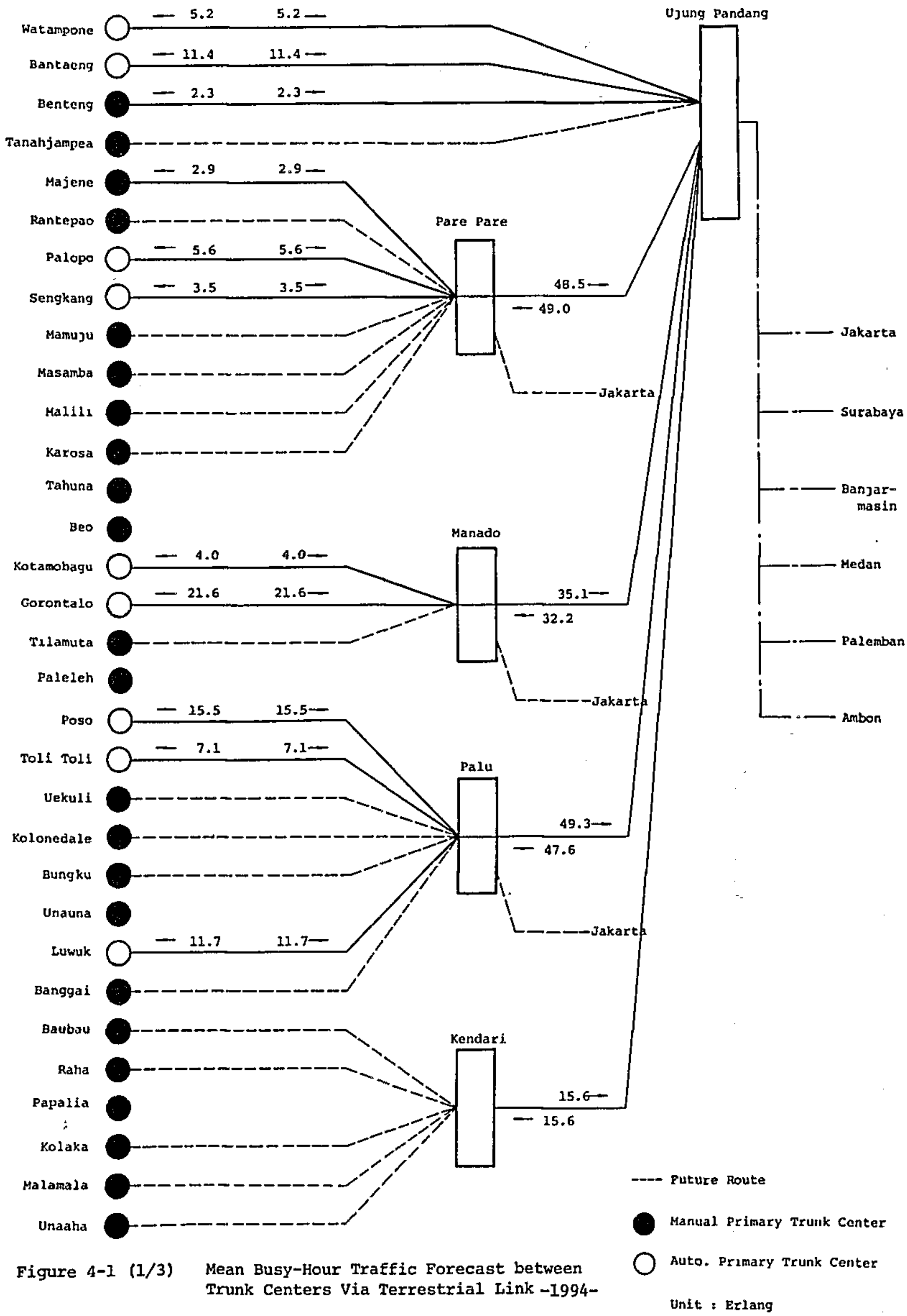


Figure 4-1 (1/3) Mean Busy-Hour Traffic Forecast between Trunk Centers Via Terrestrial Link -1994-

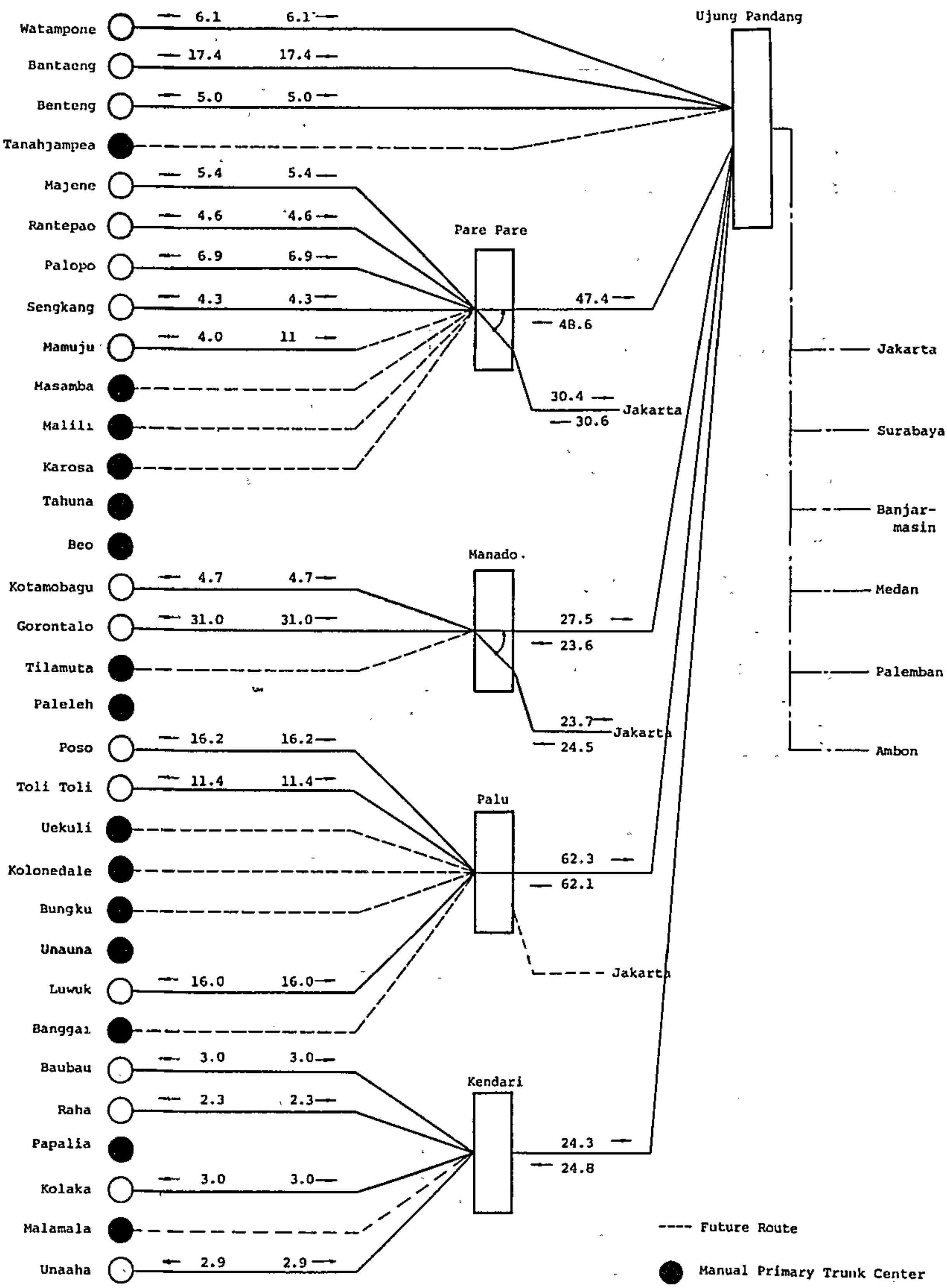


Figure 4-1 (2/3) Mean Busy-Hour Traffic Forecast between Trunk Centers Via Terrestrial Link -1999-

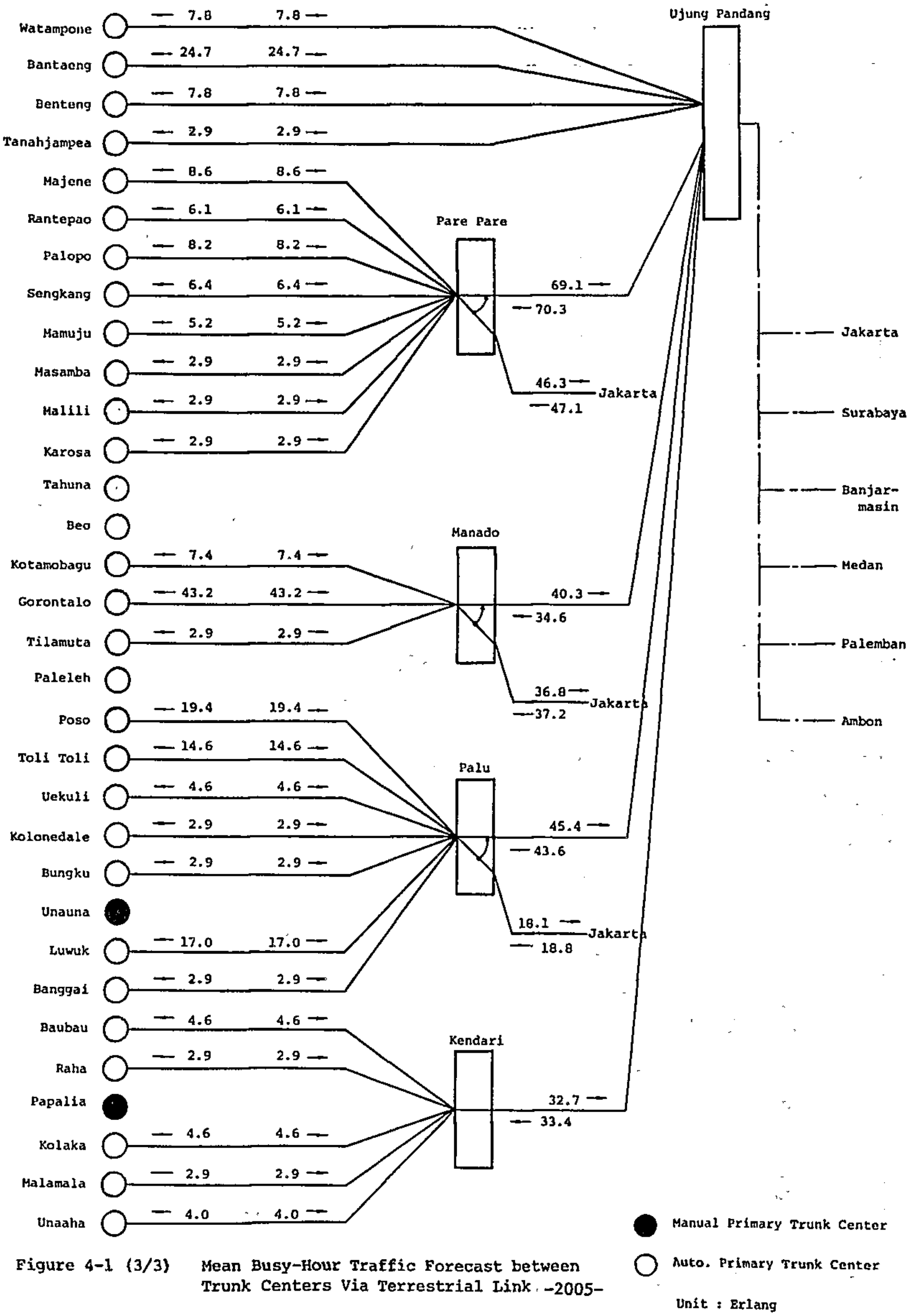


Figure 4-1 (3/3) Mean Busy-Hour Traffic Forecast between Trunk Centers Via Terrestrial Link -2005-

Table 4-10 (1/3) Mean Busy-hour Long Distance Traffic in the year of 1994

Code	Primary Area	Line Capacity	Originated Long Distance Traffic (erl.)	Terrestrial Link Ratio (%)	Via Terrestrial Traffic (erl.)	No.of cct. (OG)
411	Ujung Pandang	47,200	183.4	-	183.4	-
412	Watampone	1,200	6.5	80	5.2	13
413	Bantaeng	2,300	14.3	80	11.4	23
414	Benteng	(400)	2.9	80	2.3	8
415	Tanahjampea	(100)	0.8	0	0	-
Sub Total		51,200	207.9	-	202.3	44
421	Pare Pare	7,950	41.9	-	41.9	-
422	Majene	(450)	3.6	80	2.9	8
423	Rantepao	(450)	3.6	0	0	-
424	Palopo	1,300	7.0	80	5.6	14
425	Sengkang	600	4.4	80	3.5	10
426	Mamuju	(400)	2.9	0	0	-
427	Masamba	(200)	1.6	0	0	-
428	Malili	(200)	1.6	0	0	-
429	Karosa	(200)	1.6	0	0	-
Sub Total		11,750	68.2	-	53.9	32
431	Manado	17,000	71.9	-	71.9	-
432	Tahuna	(300)	2.4	0	0	-
433	Beo	(100)	0.8	0	0	-
434	Kotamobagu	800	5.0	80	4.0	11
435	Gorontalo	5,000	27.0	80	21.6	37
436	Tilamuta	(200)	1.6	0	0	-
437	Paleleh	(200)	1.6	0	0	-
Sub Total		23,700	110.3	-	97.5	48
451	Palu	7,100	34.1	-	34.1	-
452	Poso	3,600	19.4	80	15.5	28
453	Toli Toli	1,600	8.9	80	7.1	16
454	Uekuli	(100)	0.8	0	0	-
455	Kolonedale	(100)	0.8	0	0	-
456	Bungku	(100)	0.8	0	0	-
457	Unauna	(100)	0.8	0	0	-
458	Luwuk	2,700	14.6	80	11.7	23
459	Banggai	(100)	0.8	0	0	-
Sub Total		15,500	81.0	-	68.4	67
401	Kendari	4,000	21.6	-	21.6	-
402	Baubau	(400)	2.9	0	0	-
403	Raha	(300)	2.4	0	0	-
404	Papalia	(100)	0.8	0	0	-
405	Kolaka	(300)	2.4	0	0	-
406	Malamala	(100)	0.8	0	0	-
407	Unaaha	(300)	2.4	0	0	-
Sub Total		5,500	33.3	-	21.6	0

Table 4-10 (2/3) Mean Busy-hour Long Distance Traffic in the year of 1999

Code	Primary Area	Line Capacity	Originated Long Distance Traffic (erl.)	Terrestrial Link Ratio (%)	Via Terrestrial Traffic (erl.)	No.of cct. (OG)
411	Ujung Pandang	60,000	235.3	-	235.3	-
412	Watampone	1,400	7.6	80	6.1	14
413	Bantaeng	3,600	21.8	80	17.4	31
414	Benteng	1,000	6.3	80	5.0	13
415	Tanahjampea	(200)	1.6	0	0	-
Sub Total		66,200	272.6	-	263.8	58
421	Pare Pare	13,000	61.2	-	61.2	-
422	Majene	1,000	6.7	80	5.4	13
423	Rantepao	800	5.8	80	4.6	12
424	Palopo	1,600	8.6	80	6.9	16
425	Sengkang	800	5.4	80	4.3	11
426	Mamuju	800	5.0	80	4.0	11
427	Masamba	(300)	2.4	0	0	-
428	Malili	(300)	2.4	0	0	-
429	Karosa	(300)	2.4	0	0	-
Sub Total		18,900	99.9	-	86.4	63
431	Manado	28,000	117.8	-	117.8	-
432	Tahuna	(400)	2.9	0	0	-
433	Beo	(200)	1.6	0	0	-
434	Kotamobagu	1,100	5.9	80	4.7	12
435	Gorontalo	8,000	38.7	80	31.0	48
436	Tilamuta	(300)	2.4	0	0	-
437	Paleleh	(300)	2.4	0	0	-
Sub Total		38,300	171.7	-	153.5	50
451	Palu	8,800	42.9	-	42.9	-
452	Poso	4,500	20.3	80	16.2	29
453	Toli Toli	2,500	14.3	80	11.4	23
454	Uekuli	(200)	1.6	0	0	-
455	Kolonedale	(200)	1.6	0	0	-
456	Bungku	(200)	1.6	0	0	-
457	Unauna	(200)	1.6	0	0	-
458	Luwuk	3,700	20.0	80	16.0	29
459	Banggai	(200)	1.6	0	0	-
Sub Total		20,500	105.5	-	86.5	81
401	Kendari	5,000	22.5	-	22.5	-
402	Baubau	600	3.8	80	3.0	9
403	Raha	400	2.9	80	2.3	8
404	Papalia	(200)	1.6	0	0	-
405	Kolaka	600	3.8	80	3.0	9
406	Malamala	(200)	1.6	0	0	-
407	Unaaha	500	3.6	80	2.9	9
Sub Total		7,500	39.8	-	33.7	35

Table 4-10 (3/3) Mean Busy-hour Long Distance Traffic in the year of 2005

Code	Primary Area	Line Capacity	Originated Long Distance Traffic (erl.)	Terrestrial Link Ratio (%)	Via Terrestrial Traffic (erl.)	No.of cct. (OG)
411	Ujung Pandang	90,000	347.4	-	347.4	-
412	Watampone	1,800	9.7	80	7.8	17
413	Bantaeng	5,400	30.9	80	24.7	41
414	Benteng	1,800	9.7	80	7.8	17
415	Tanahjampea	500	3.6	80	2.9	9
Sub Total		99,500	401.3	-	390.6	84
421	Pare Pare	19,500	85.0	-	85.0	-
422	Majene	1,700	10.7	80	8.6	18
423	Rantepao	1,200	7.6	80	6.1	14
424	Palopo	1,900	10.3	80	8.2	18
425	Sengkang	1,200	8.0	80	6.4	15
426	Mamuju	1,200	6.5	80	5.2	13
427	Masamba	500	3.6	80	2.9	9
428	Malili	500	3.6	80	2.9	9
429	Karosa	500	3.6	80	2.9	9
Sub Total		28,200	138.9	-	128.2	105
431	Manado	42,000	173.7	-	173.7	-
432	Tahuna	500	3.6	0	0	-
433	Beo	500	3.6	0	0	-
434	Kotamobagu	1,700	9.2	80	7.4	16
435	Gorontalo	12,000	54.0	80	43.2	63
436	Tilamuta	500	3.6	80	2.9	9
437	Paleleh	500	3.6	0	0	-
Sub Total		58,400	251.3	-	227.2	88
451	Palu	14,700	59.3	-	59.3	-
452	Poso	5,400	24.3	80	19.4	34
453	Toli Toli	3,250	18.3	80	14.6	27
454	Uekuli	800	5.8	80	4.6	12
455	Kolonedale	500	3.6	80	2.9	9
456	Bungku	500	3.6	80	2.9	9
457	Unauna	(300)	2.4	0	0	-
458	Luwuk	4,700	21.2	80	17.0	31
459	Banggai	500	3.6	80	2.9	9
Sub Total		30,650	142.1	-	123.6	131
401	Kendari	6,000	27.0	-	27.0	-
402	Baubau	900	5.7	80	4.6	12
403	Raha	500	3.6	80	2.9	9
404	Papalia	(300)	2.4	0	0	-
405	Kolaka	900	5.7	80	4.6	12
406	Malamala	500	3.6	80	2.9	9
407	Unaaha	800	5.0	80	4.0	11
Sub Total		9,900	53.0	-	46.0	53

Table 4-13 Non-Telephone Service Traffic Forecast

Unit: Erlang

Service	Area	1980	1989	1994	1999	2005
Telex	Ujung Pandang	4.0	16.5	29.5	45.0	64.0
	Kendari	0.5	1.5	2.5	4.0	5.5
	Palu	1.5	6.0	11.0	17.0	24.0
	Manado	2.5	10.5	18.5	28.0	40.0
	Total	8.5	34.5	61.5	94.0	133.5
New Service	Ujung Pandang	-	1.5	4.5	10.5	31.0
	Kendari	-	0.5	0.5	1.0	3.5
	Palu	-	0.5	0.5	1.5	4.5
	Manado	-	1.0	2.5	6.0	17.5
	Total	-	3.5	8.0	19.0	56.5
Telegram	Ujung Pandang	5.5	12.5	16.0	19.0	19.0
	Kendari	1.0	2.0	2.5	3.0	3.0
	Palu	2.0	5.0	6.5	7.5	7.5
	Manado	3.5	8.5	11.0	12.5	12.5
	Total	12.0	28.0	36.0	42.0	42.0
Total	Ujung Pandang	9.5	30.5	50.0	74.5	114.0
	Kendari	1.5	4.0	5.5	8.0	12.0
	Palu	3.5	11.5	18.0	26.0	36.0
	Manado	6.0	20.0	32.0	46.5	70.0
	Total	20.5	66.0	105.5	155.0	232.0

4-4. Calculating of Required Number of Circuits

4-4-1 Preconditions

For calculation of the number of circuits required of the exchange connected to both terrestrial transmission link and satellite link, specific requirements relating to network configuration, including transmission route selection priority and alternate routing method, must first be clarified. Following are preconditions that are binding when the required number of circuits in this Project is calculated.

(1) Satellite link to be used for SLDD service at Primary and Secondary Centers is assumed to be DA (Demand Assignment) route. The assumption is made so as to avoide double or triple hop connections of satellite links.

(2) For outgoing circuit selection at toll exchange, assumption is that terrestrial route be selected on priority basis while satellite route selection be as alternative route.

(3) High usage route establishment be limited to route where traffic volume is 20 Erlangs or more. This is because all switching equipment is to be digital type completely relieved of call loss, and because digital transmission system is to be adopted and effectively used.

(4) Traffic to be connected to distant exchange where terrestrial transmission link cannot be utilized but satellite link only is available is to be included in traffic distributed to DA route.

4-4-2 Required Circuits in Telephone Network

(1) Between Primary and Secondary Centers

Required number of circuits is calculated from traffic calculated to be carried on terrestrial transmission route (A_{p-s}). In this calculation, the following conditions are used:

a) To cope with traffic variations, traffic be multiplied by coefficient specified below and traffic volume thus obtained be used for calculation of required number of circuits.

$A_{p-s} < 30$ Erl. : 1.2

$P_{p-s} \geq 30$ Erl. : 1.15

b) Assuming call loss rate to be 1%, required number of circuits be calculated, using no-delay full-availability trunk group load table (Erlang-B-Formula).

(2) Between Secondary and Tertiary Centers

a) Final Route

- To cope with traffic variations, the same coefficient and call loss rate as between Primary and Secondary Centers are used.
- For final trunks without overflow traffic, required number is calculated, using no-delay full-availability trunk group load table.
- For final trunks with overflow traffic, the number obtained from no-delay full-availability trunk group load table is increased by 7%.

b) High Usage Route

- According to CCITT Manual, required number of high usage route circuits is to be calculated, using the condition wherein the following formula takes effect:

$$LTC < \frac{ATC}{K}$$

where

LTC: Traffic volume to be carried by last trunk in high usage route

ATC: Traffic increment that requires one additional final route circuit

K : Final route cost vs high usage route cost ratio

- Assume that final route is of 10 circuits to 150 circuits size. Then, ATC is 0.8 Erl. on the average. Also assume that final route vs high usage route cost ratio is 1.1, hence LTC = 0.75 Erl. By this condition, required number of high usage route circuits is calculated.

(3) Results of calculation concerning required number of circuits between trunk centers appear in Figure 4-2.

4-4-3 Required circuits for Non-Telephone Services

Required number of inter-exchange trunks for non-telephone services in Sulawesi area appears in Table 4-14.

4-4-4 Circuit Grouping by Sections

Telephone circuits and non-telephone circuits as distributed among sections on transmission route are illustrated in Figure 4-3.

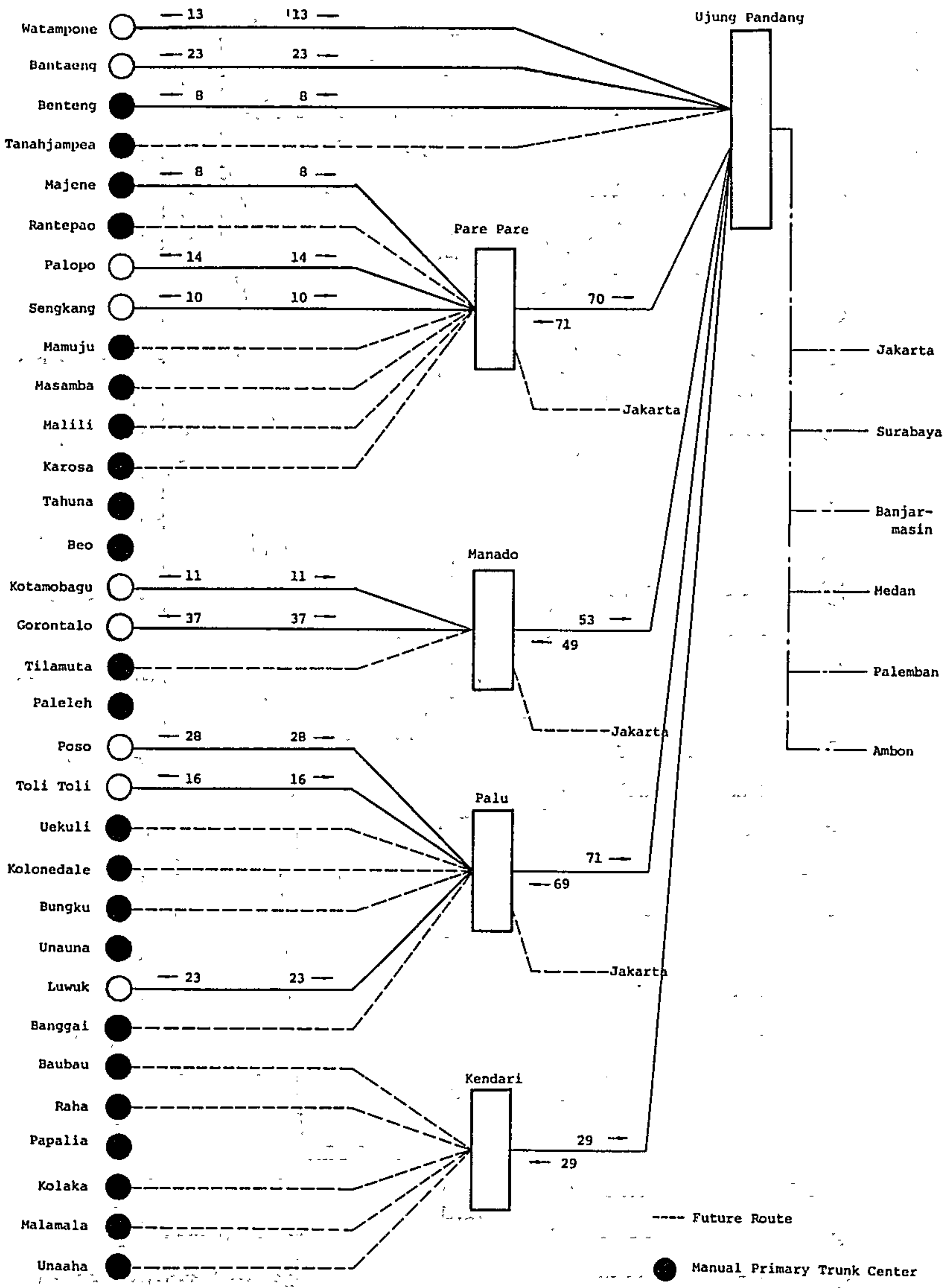


Figure 4-2 (1/3) Number of Circuits between Trunk Centers Via Terrestrial Link -1994-

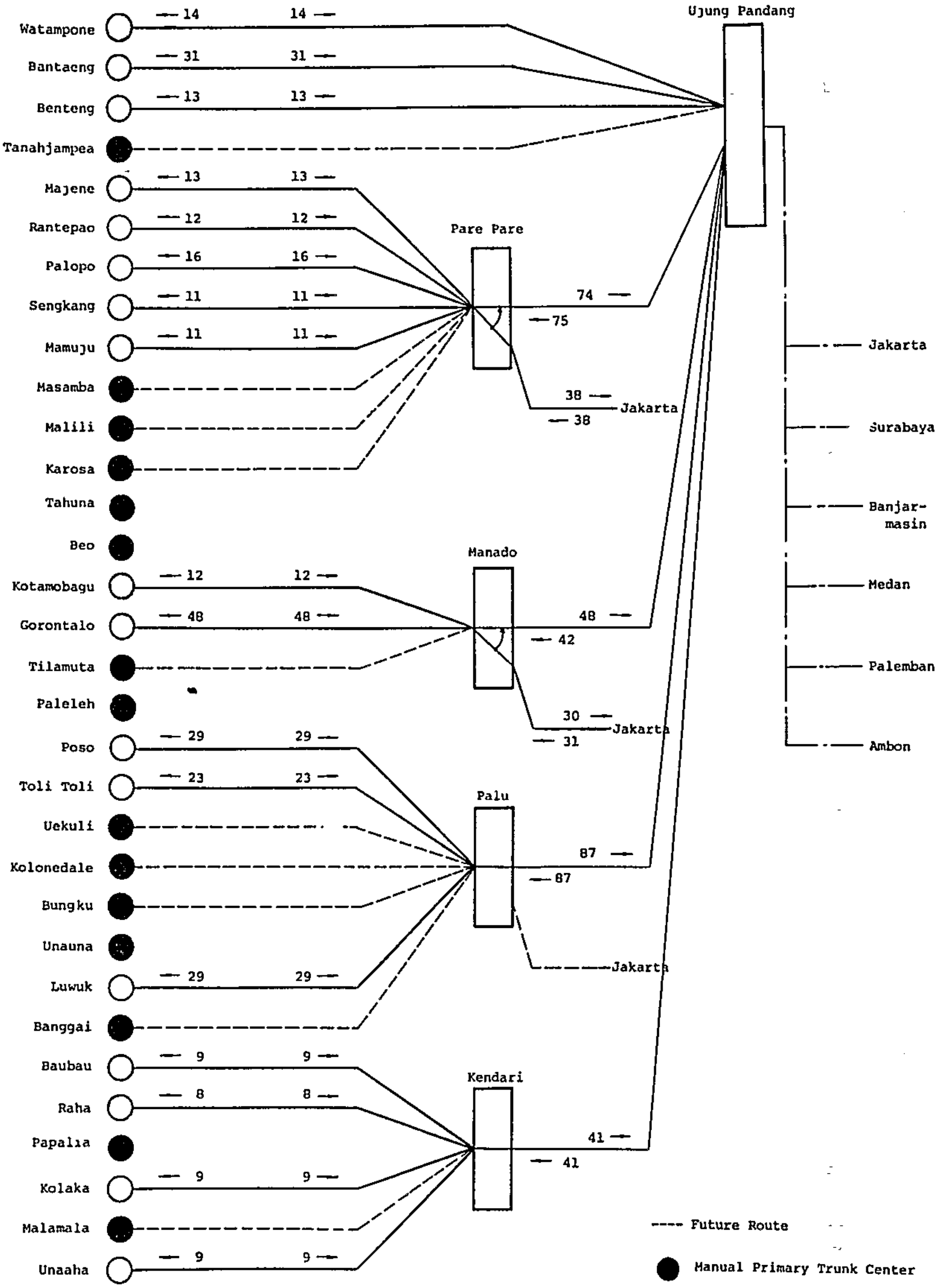


Figure 4-2 (2/3) Number of Circuits between Trunk Centers Via Terrestrial Link -1999-

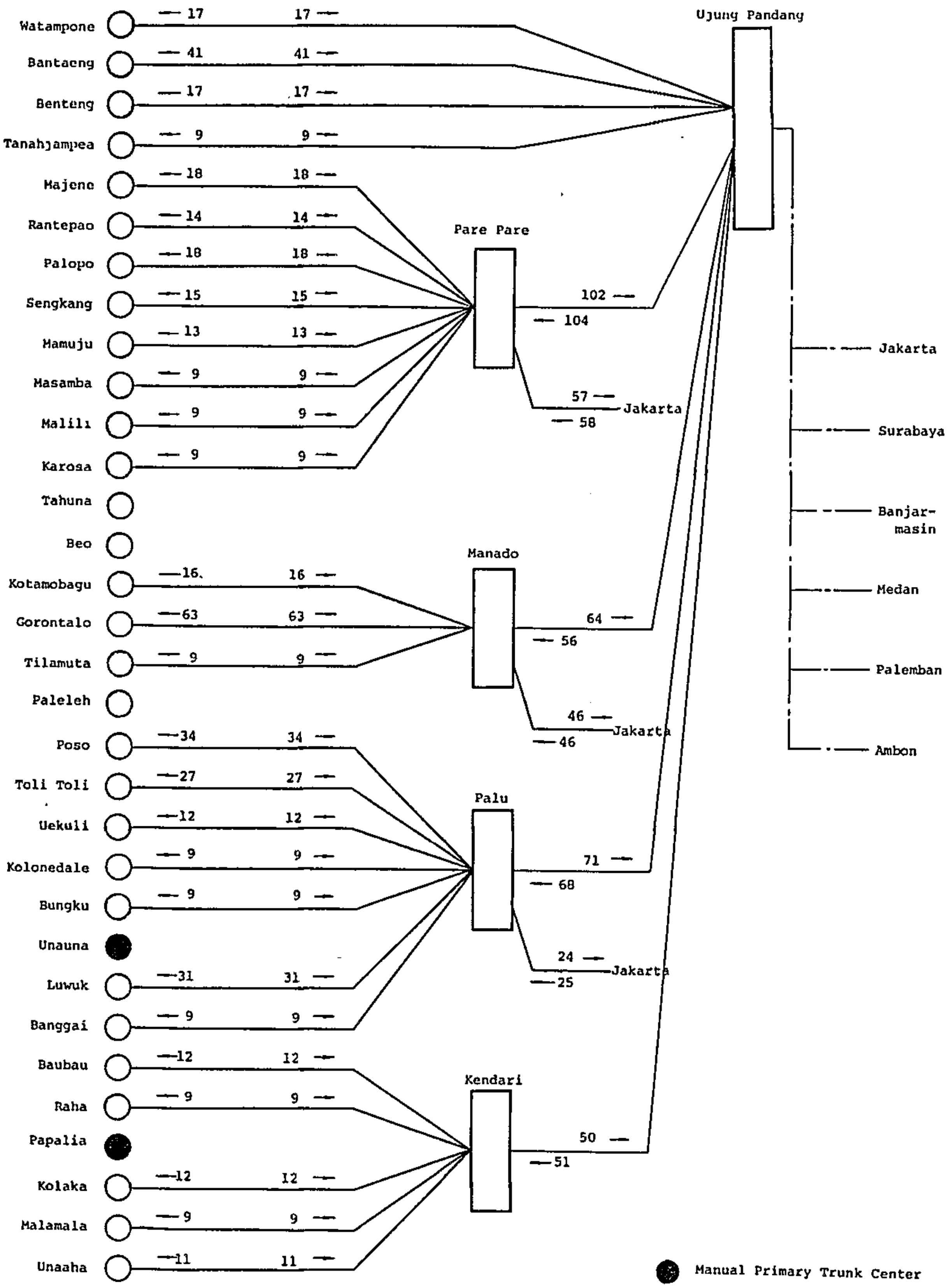


Figure 4-2 (3/3) Number of Circuits between Trunk Centers Via Terrestrial Link -2005-

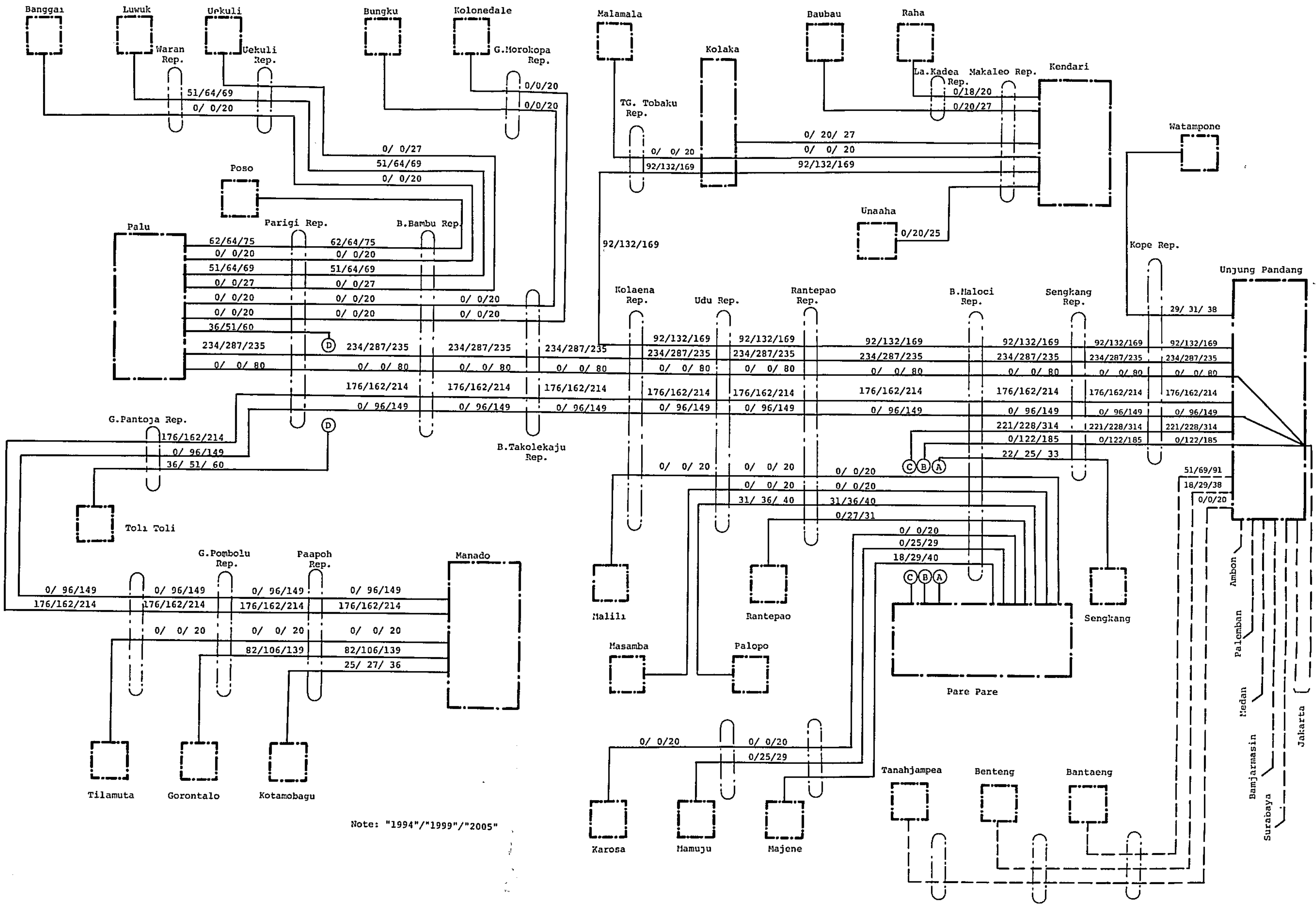


Figure 4-3 Circuit Grouping Diagram (Case 1)

Table 4-14 No. of Circuits for Non-Telephone Services and Leased Circuits

Main Offices	No. of Circuits (IC + OG)			from / to
	1994	1999	2005	
Pare Pare	41	80	139	Ujung Pandang or Jakarta
Manado	56	78	123	
Palu	84	97	105	
Kendari	32	42	49	

5. TRANSMISSION ROUTE PLAN AND SYSTEM DESIGN

5. Transmission Route Plan and System Design

5-1. Transmission Route Plan

Transmission routes to be realized by this Project are illustrated in Figure 3-1.
These transmission routes are to be of digital system. The reason is that the digital transmission system is compatible with digital switching equipment to be adopted on the routes: hence, it is economically advantageous.

Based on the circuit grouping plan described in Chapter 4, selection is made for two kinds of digital radio systems on main route. They are of 6 GHz band (upper band) with transmission capacities of 480 CH and 1,440 CH per RF CH, respectively. Also made is the selection, on spur routes, for two kinds of digital radio systems with capacities of 60 CH and 240 CH, respectively, in 2 GHz band.

For part of spur routes, where hop distance is short, cable PCM system is selected.

Details about the selection of those transmission systems are described in the paragraph 5-2.

Each radio system is to be protection RF CH switchover system, or, more precisely, the system composed of working RF CH plus protection RF CH which is commonly known as (n + 1) system. Radio system of this type contributes to transmission system reliability. Economically also, such system is advantageous.

With (1 + 1) system adopted on both main and spur routes, circuit requirements up to the year 2005 can be satisfied. However, in 11 radio repeater sections between Ujung Pandang and Kalaena Repeater*, the main route, one RF CH must be additionally installed during REPELITA VI period.

*: Kalaena Repeater Station is a branching station to kendari route.

Following are the points that required utmost care in transmission route selection:

(1) To select radio repeater sites near the existing roads so as to do with shortest possible access roads. This is to reduce initial cost of transmission route construction to the available minimum.

(2) To make site selection with emphasis on avoiding influence from ground and sea reflections.

(3) To avoid as much as possible radio repeater construction on small islands difficult of access. This is to ease maintenance and operation.

(4) To avoid radio repeater construction in such areas where natural calamities, such as volcanic eruptions and heavy rainfalls, are anticipated.

As an alternative plan for main route from Palu to Manado, Master Plan proposes oversea propagation route (Plan B) that extends via Togian islands.

This transmission route includes two long oversea sections. Each of these section length reaches about 100 km. In these oversea sections, transmission system performance deteriorates extremely due to fading. However, no technical measure to relieve such system performance deterioration is yet established. Furthermore, Togian islands that lie on the route are not proper as radio repeater site because they are difficult of access, hence inconvenient for maintenance work.

Therefore, in this Project, Route Plan A proposed by Master Plan, i.e., the overland route from Palu to Manado, is adopted.

5-2. Selection of Transmission Systems

5-2-1 Digital Radio System

For radio system to be adopted in this Project, studies were made on presently available digital radio systems including UHF and SHF band systems. Optimum systems selected are 2 GHz system and 6 GHz (upper band) system. Reasons for this selection are described below.

(1) Selection of Optimum Radio Frequency Band

a) Selection of 2 GHz Band

Out of UHF band, 800 MHz to 2,000 MHz frequency band is commonly used for radio relay system. The following are the reasons for selection of 2 GHz band, this time.

From viewpoint of circuit formation, general trend is that the higher the frequency band, the higher the equipment cost. On the other hand, when low frequency band, especially 800 MHz band, is used and space diversity is required, antenna spacing is bound to widen. Hence, tower height increases and so does tower construction cost also. Depending upon the number of sections where such low frequency band is used, overall system cost increases.

Mobile communication service that uses 800 MHz band is being put into practice in many foreign countries. This frequency band is used in many cases of small capacity, short distance land-fixed communication also. Thus, in Indonesia, too, it is preferable that this frequency band be secured for use in mobile communication or in local/rural communication, such as between Primary Center and Local exchange.

For radio frequency arrangement for 2 GHz system, CCIR Recommendation (Rec. 283-3) is available. 2 GHz system is already on utility stage.

b) Selection of 6 GHz Band (Upper Band)

SHF band, 3 GHz to 30 GHz band is in the selection range. The band selected is 6 GHz band (upper band). Reasons for selection follow:

- In 10 GHz or higher band, propagation attenuation due to rainfall is great so that short repeater spacing is required. Area of this Project is an area of much rainfall: therefore, the area is not fit for long haul transmission system, using this frequency band.

- 4 GHz band and 6 GHz band (lower band) are allocated to domestic communication satellite system. To avoid frequency interference, these bands should not be used.

- The remaining bands available are 5 GHz band, 6 GHz band (upper band), 7 GHz band and 8 GHz band. Out of these, fittest for digital system, long haul transmission system will be 6 GHz band. That is, this band will be earliest developed and practiced, and most rapidly diffused. This judgement can be reached from the development trend of the conventional analog system.

(2) Selection of Transmission Capacity and Modulation System

2 GHz and 6 GHz band digital radio systems of different transmission capacities and modulation systems are available.

Selection is made for undermentioned transmission capacities and modulation systems as being optimum to apply in this Project.

	Transmission Capacity	Modulation System
2 GHz system	60 CH (2,048 kbit/s x 2)	4 PSK
	240 CH (8,448 kbit/s x 2)	4 PSK
6 GHz system	480 CH (34,368 kbit/s x 1)	4 PSK
	1,440 CH (34,368 kbit/s x 3)	8 PSK

In the above selection, route by route circuit grouping results were duly considered. On the following points also, special care was exercised:

- To standardize all systems as much as possible so as to ease maintenance and operation.

- Transmission system that uses 16 QAM modulation system requires space diversity, as well as automatic equalizer in each section. Hence higher cost, compared with the case where other modulation system is used.

- For 2 GHz system, there are two classifications: narrow band system and wide band system. One differs from the other in frequency arrangment. Considered from viewpoint of effective frequency utilization, narrow band system is preferred.

(3) Application of Selected Transmission Systems

For application of selected transmission systems to main and spur routes, the following considerations are made:

a) Spur Route

Circuit requirements on whichever spur route of this Project are less than 240 CH in terms of telephone channels. Hence the application of 2 GHz system to spur routes for reason of econmy in transmission route construction.

b) Main Route

On main route, TV signal transmission via protection RF channel is planned. Thus, on main route, transmission system with bit rate of at least 34 Mbit/s (equivalent to 480 CH in terms of telephone channels) is required. Hence the application of 6 GHz system to main route.

(Note: Study to standardize bit rate of TV signal transmission is being made by CMTT. For this bit rate, 34.368 Mbit/s is being studied. Refer to CCIR Rep. 646-1.)

5-2-2 Cable Leading-in System

Cable leading-in system selected in this Project and sections where it will be applied are:

System: Cable PCM system
(bit rate: 2,048 kbit/s)

Sections:	Uekuli - Radio Repeater	7 km
	Tilamuta - Radio Repeater	15 km
	Tanahjampea - Radio Repeater	10 km

Comparative study for radio leading-in system and cable leading-in system is made in ANNEX-4.

5-3. Channel Accommodation in Transmission Route

Based on circuit grouping as per Chapter 4, channel accommodations are made, meeting forecasted demand as of 1994, 1999 and 2005. Channel accommodation plans are in Figure 5-1 to Figure 5-3.

Channel accommodations are on these assumptions:

(1) Exsting Ujung Pandang - Pare Pare coaxial cable system is not to be used in this Project.

(2) Ujung Pandang - Pare Pare coaxial cable system is to be utilized as follows:

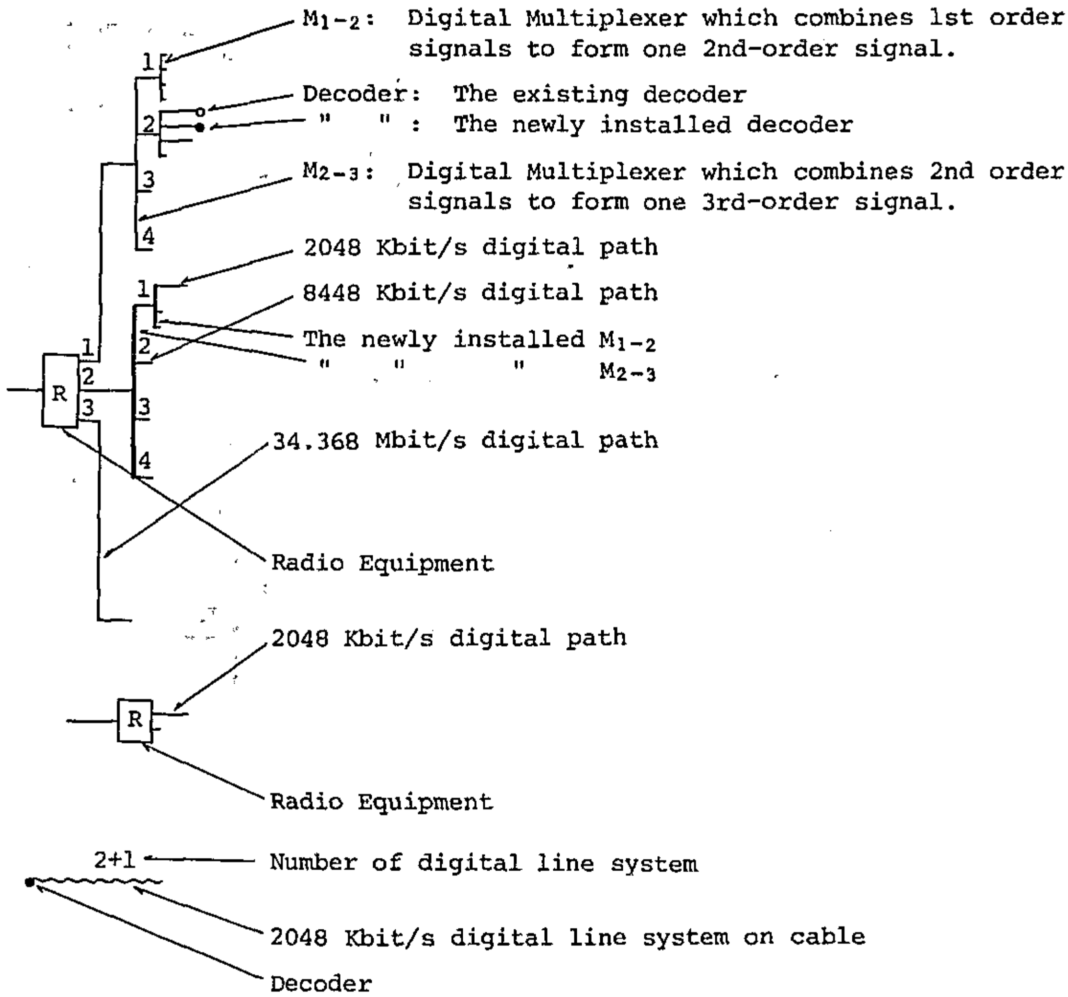
When four manual exchanges presently scattered on that cable system route are remodelled into automatic exchanges in the future, the cable system will be utilized as transmission route between the remodelled four automatic exchanges and Ujung Pandang.

(3) Existing analog 2-wire toll switching equipment at Pare Pare is to be replaced with digital equipment in 1989, the year in which service life of existing analog system is supposed to terminate. Meanwhile, the year 1989 is 20 years after the existing analog 2-wire toll switching equipment was first established.

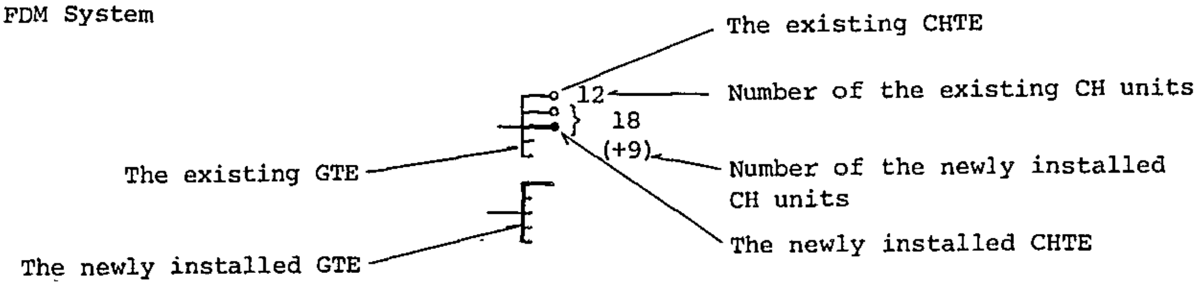
List of Abbreviations of Exchange Names

Jakarta	JK
Ujung Pandang	UP
Pare Pare	PP
Manado	MN
Palu	PL
Kendari	KD
Watampone	WPN
Bantaeng	BTE
Benteng	BEN
Tanahjampea	TJP
Rantepao	RTP
Palopo	PLP
Masamba	MSB
Malili	MLI
Karosa	KRS
Kotamobagu	KTM
Gorontalo	GRT
Tilamuta	TLM
Poso	PSO
Toli Toli	TOL
Uekuli	UKL
Kolonedare	KLD
Bungku	BNK
Luwuk	LWK
Banggai	BAG
Baubau	BAU
Raha	RAH
Kolaka	KLK
Malamala	MAL
Unaaha	UNH

1. PCM System



2. FDM System



Symbols used in Channel Accommodation Plan

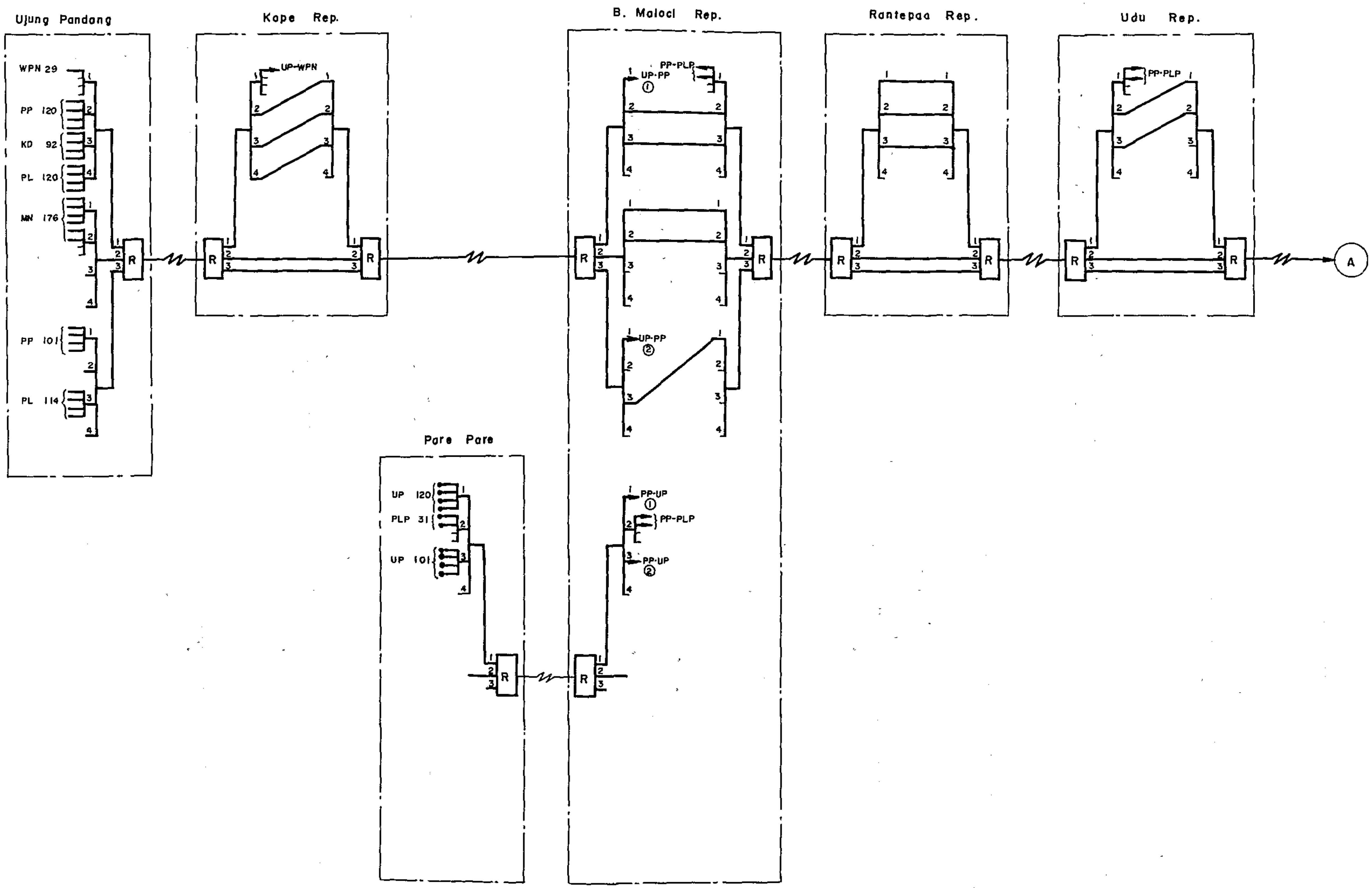


Figure 5-1 (1/6) Channel Accommodation Plan on Initial Stage

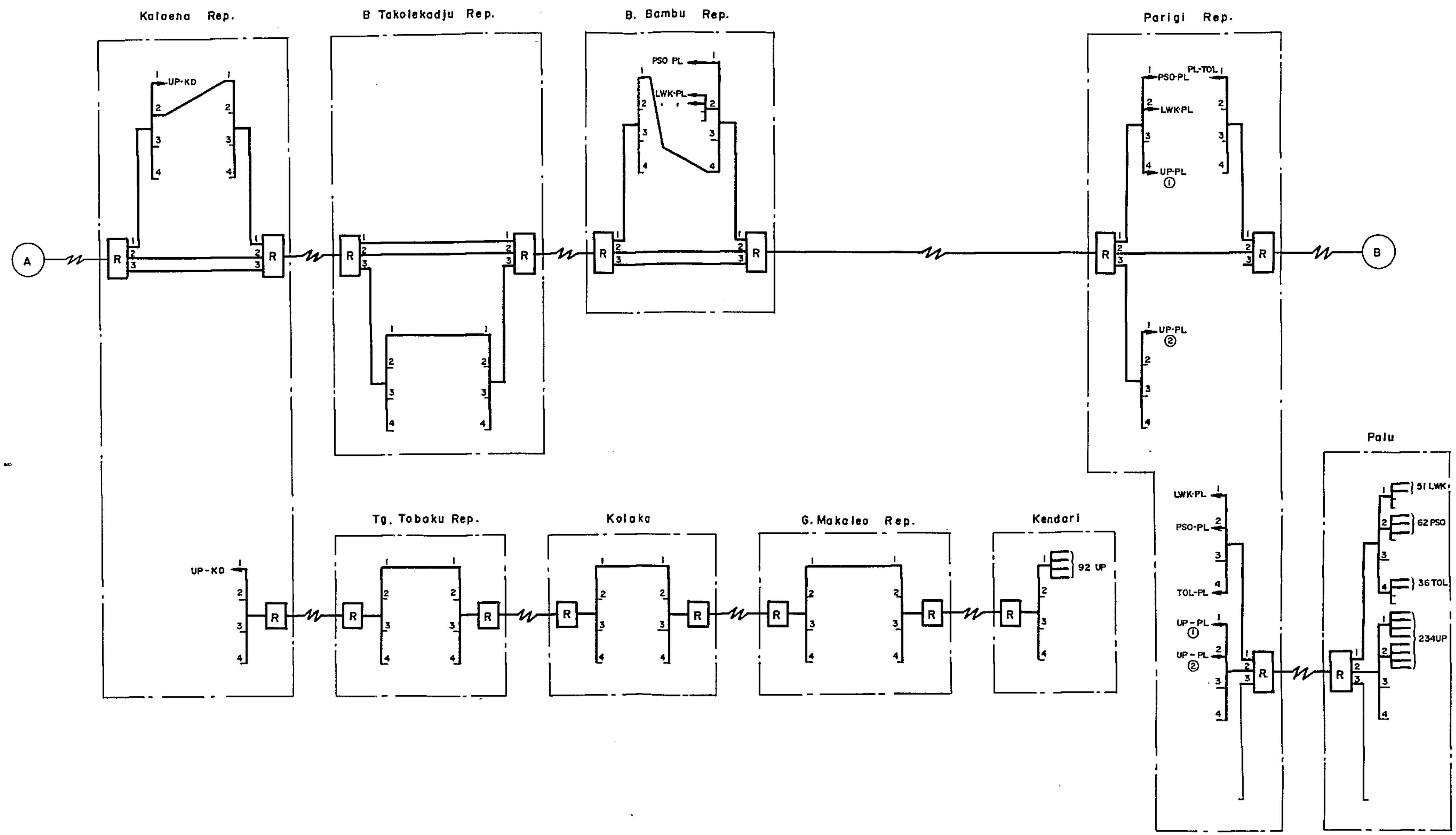


Figure 5-1 (2/6) Channel Accommodation Plan on Initial Stage

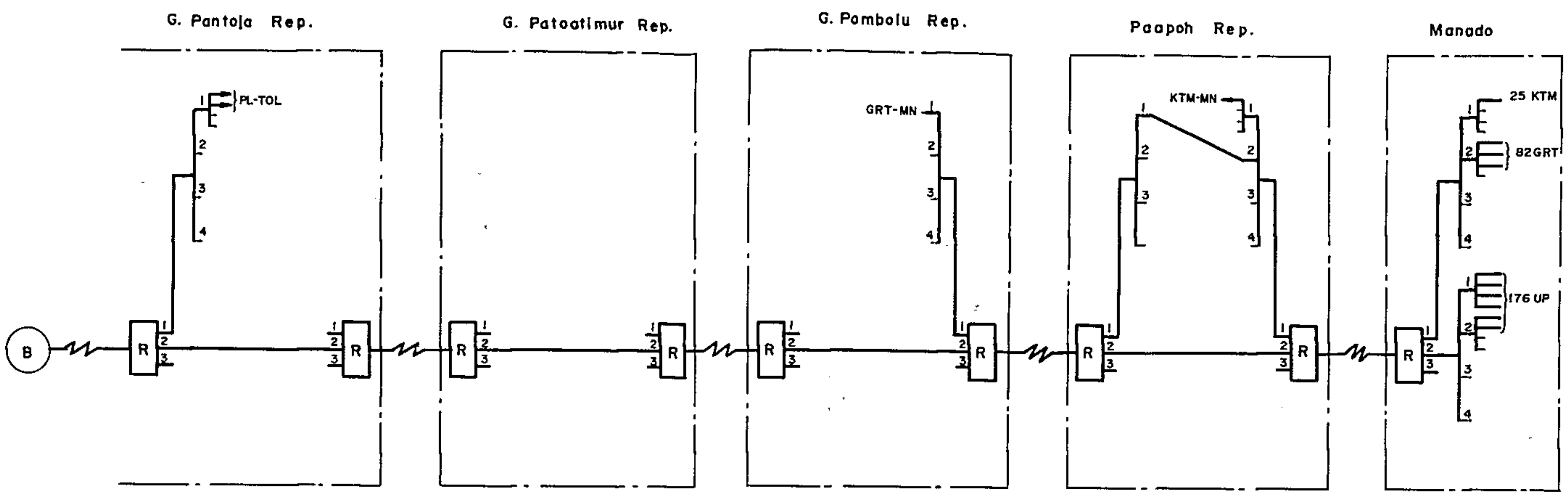


Figure 5-1 (3/6) Channel Accommodation Plan on Initial Stage

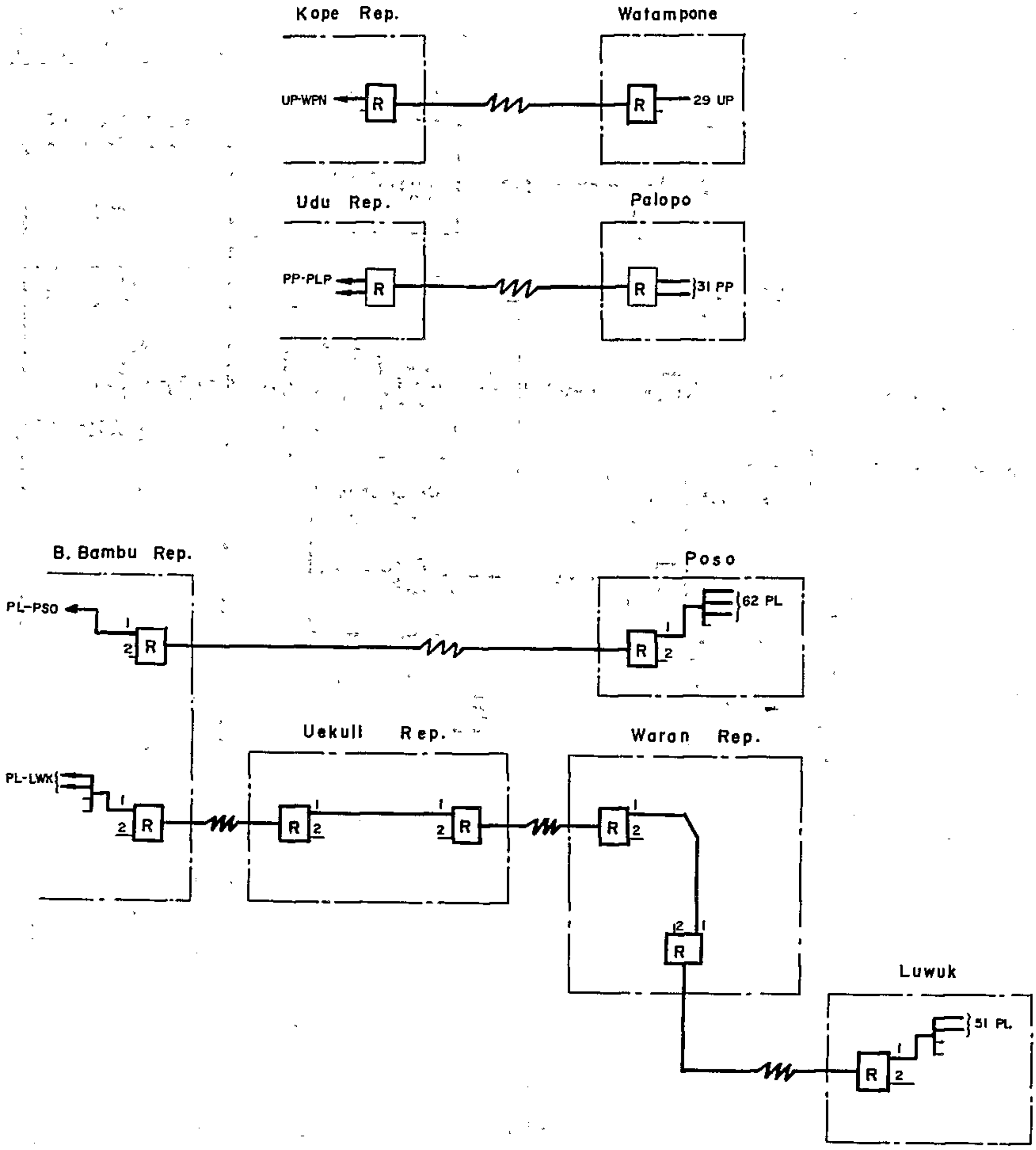


Figure 5-1 (4/6) Channel Accommodation Plan on Initial Stage

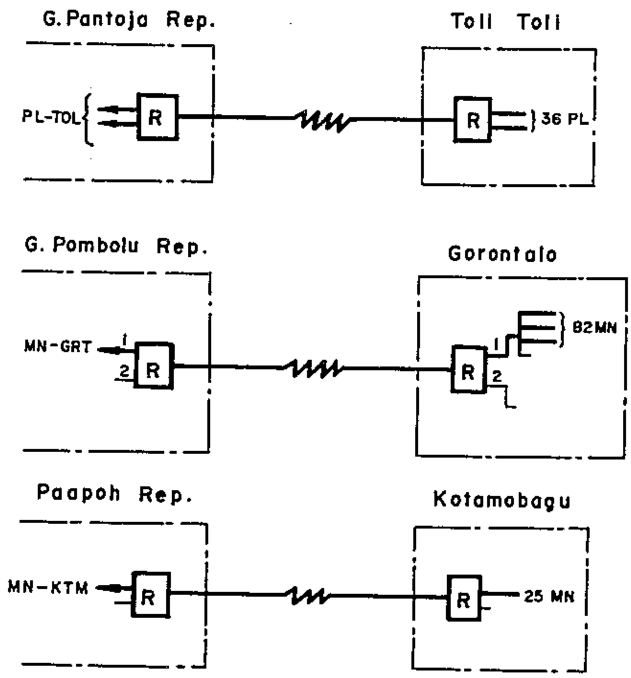


Figure 5-1 (5/6) Channel Accommodation Plan on Initial Stage

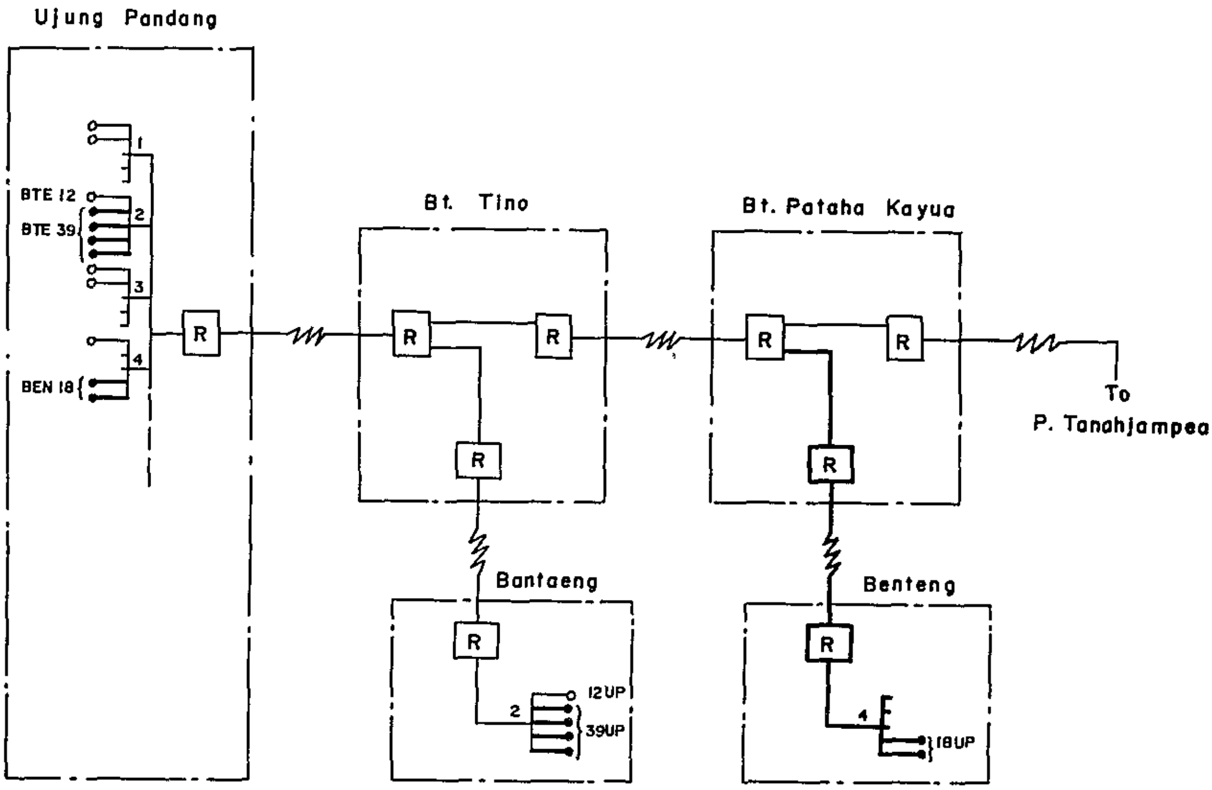


Figure 5-1 (6/6) Channel Accommodation Plan on Initial Stage

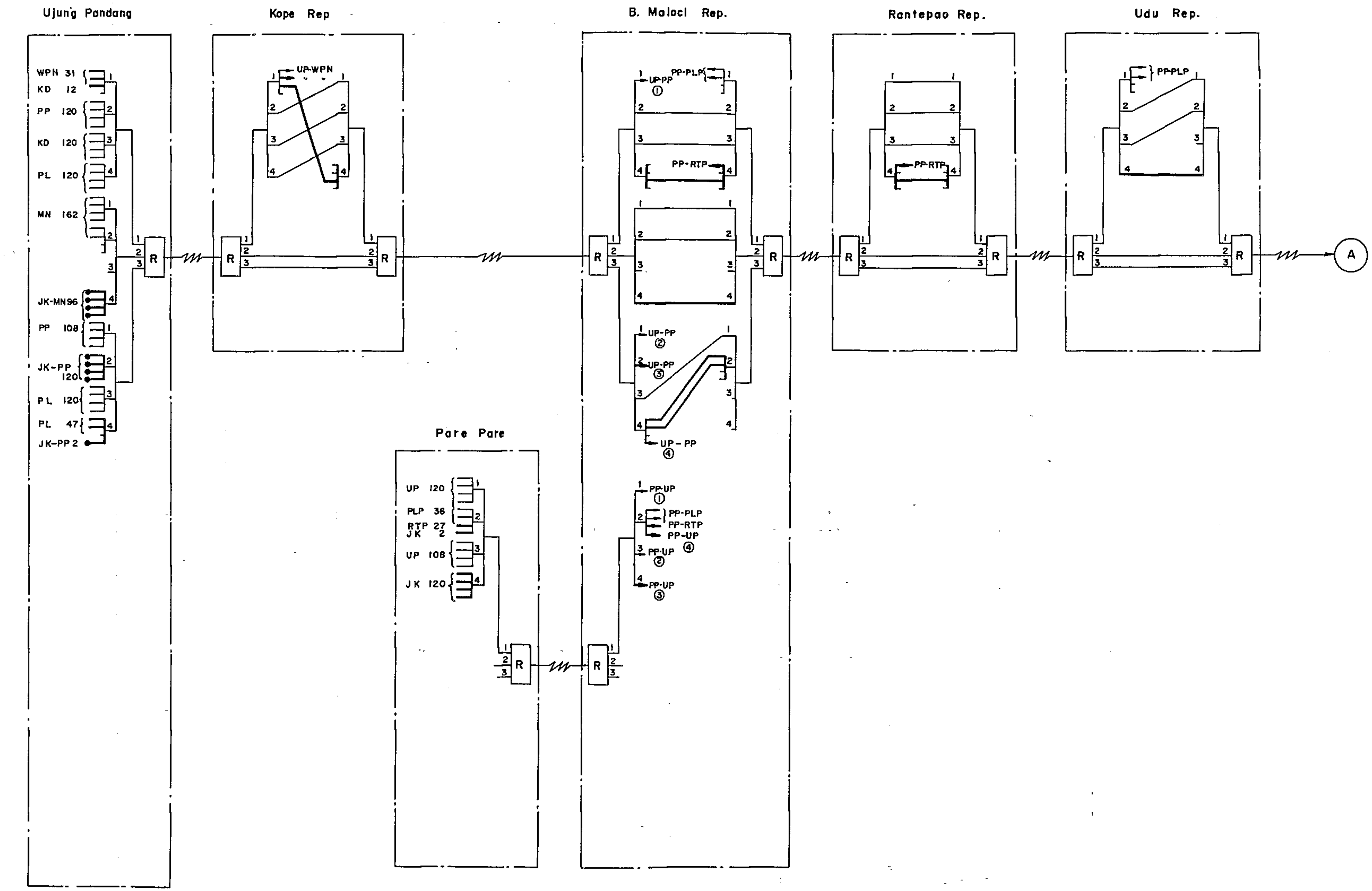


Figure 5-2 (1/6) Channel Accommodation Plan on Intermediate Stage

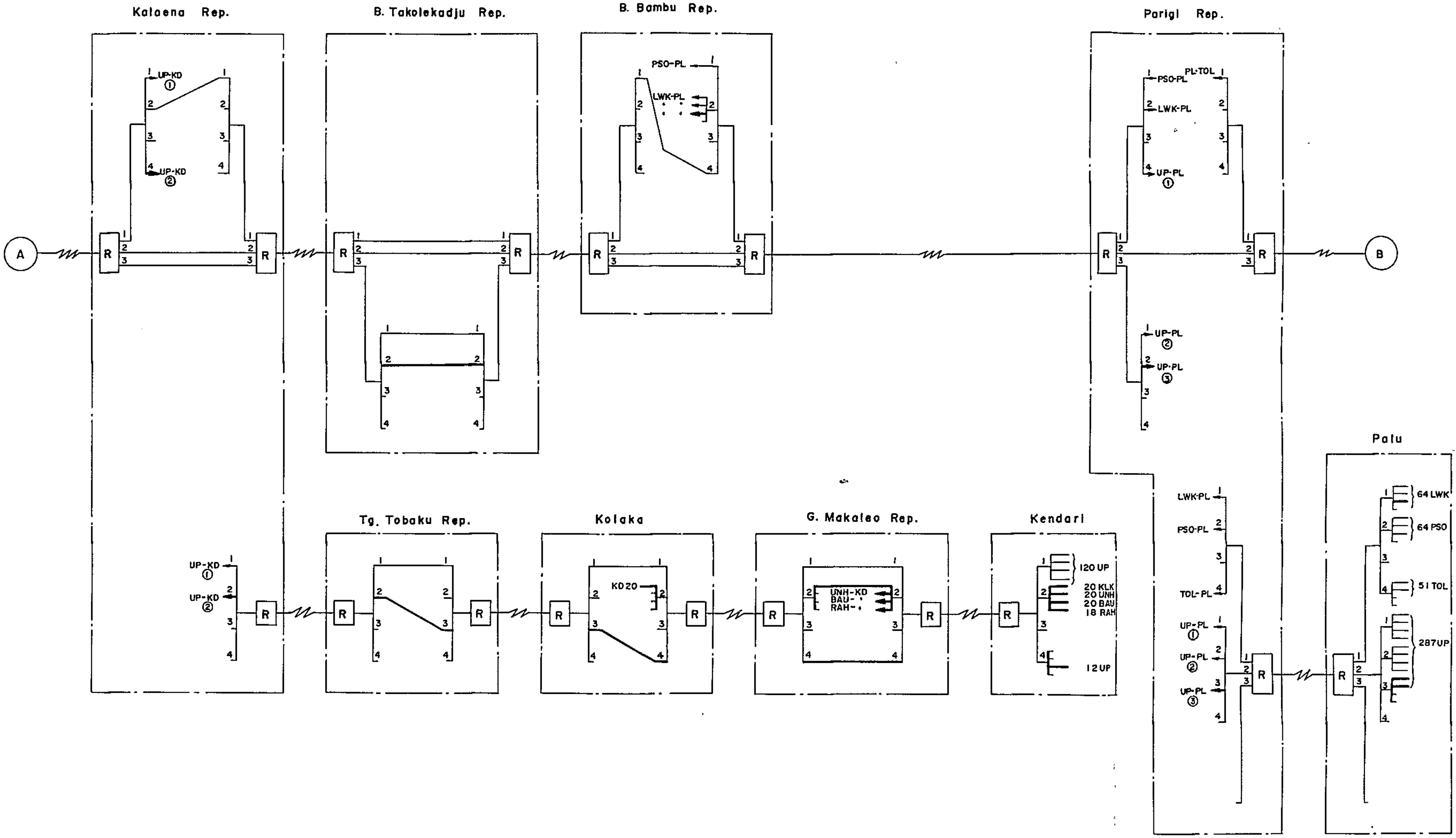


Figure 5-2 (2/6) Channel Accommodation Plan on Intermediate Stage

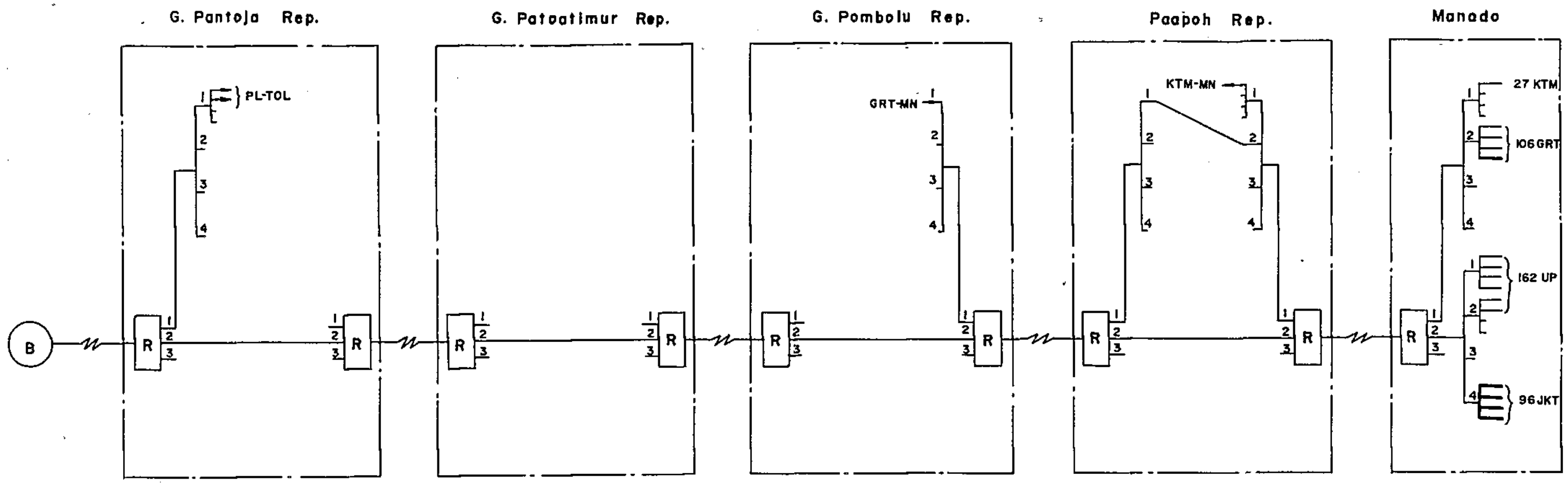


Figure 5-2 (3/6) Channel Accommodation Plan on Intermediate Stage

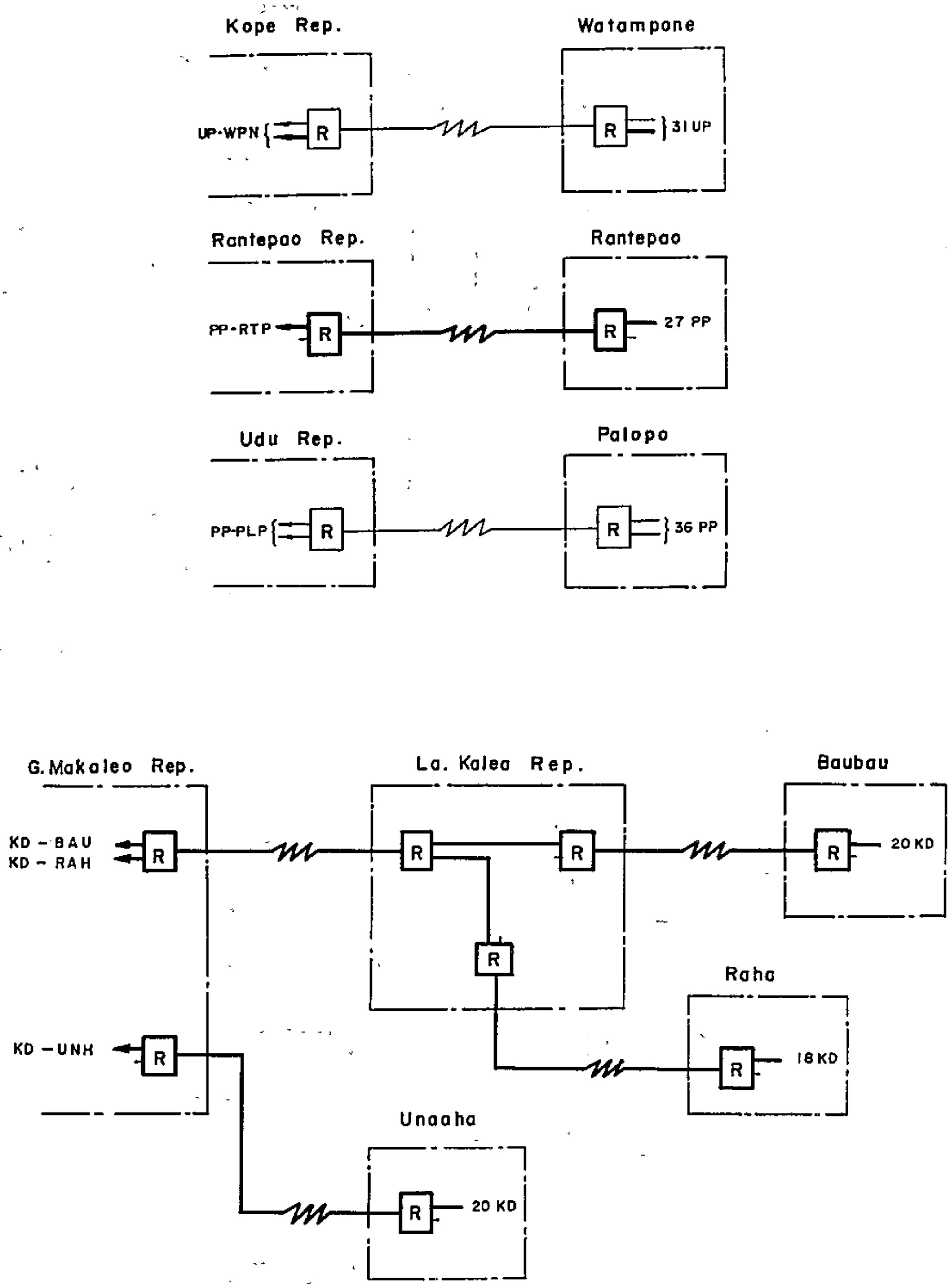


Figure 5-2 (4/6) Channel Accommodation Plan on Intermediate Stage

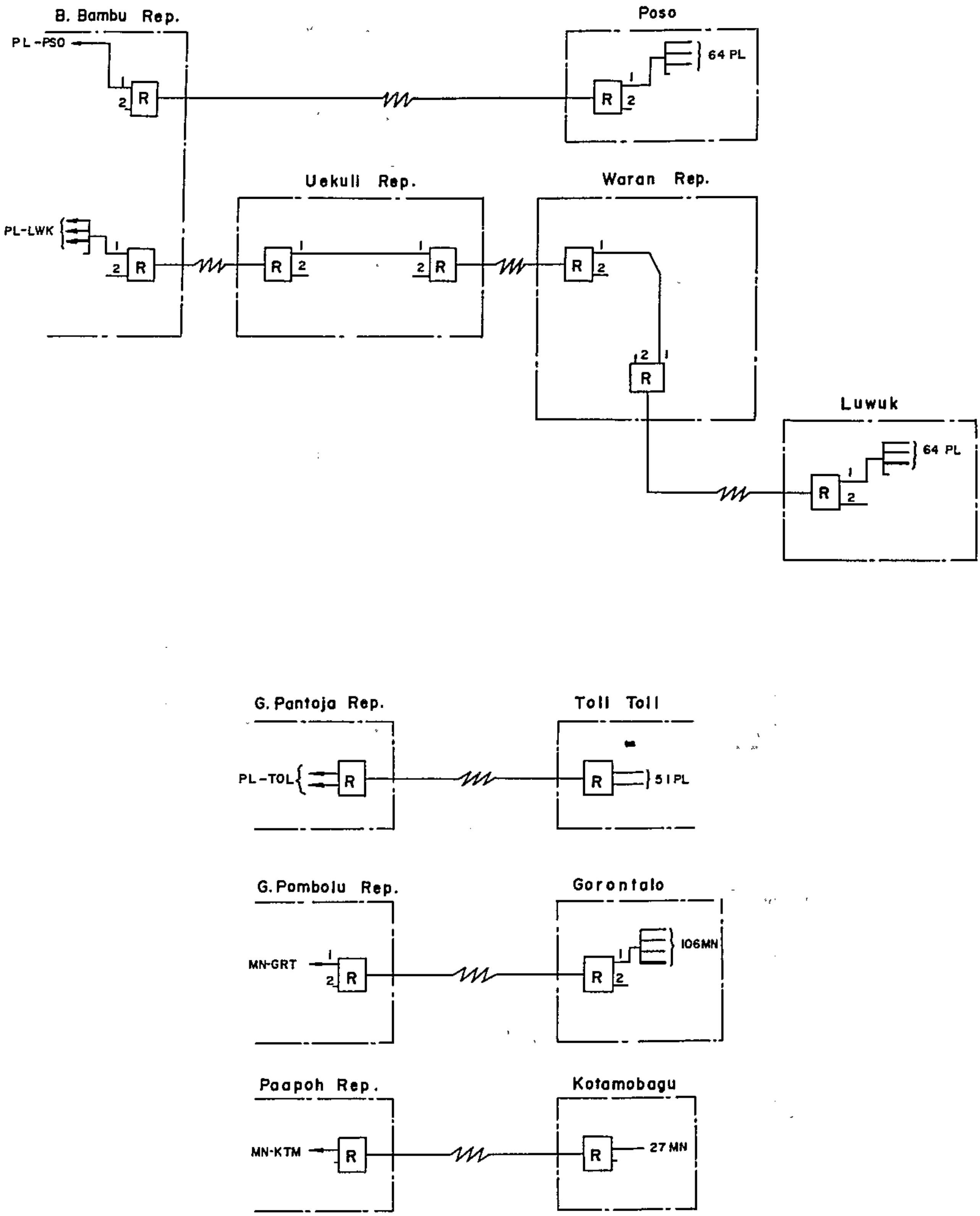


Figure 5-2 (5/6) Channel Accommodation Plan on Intermediate Stage

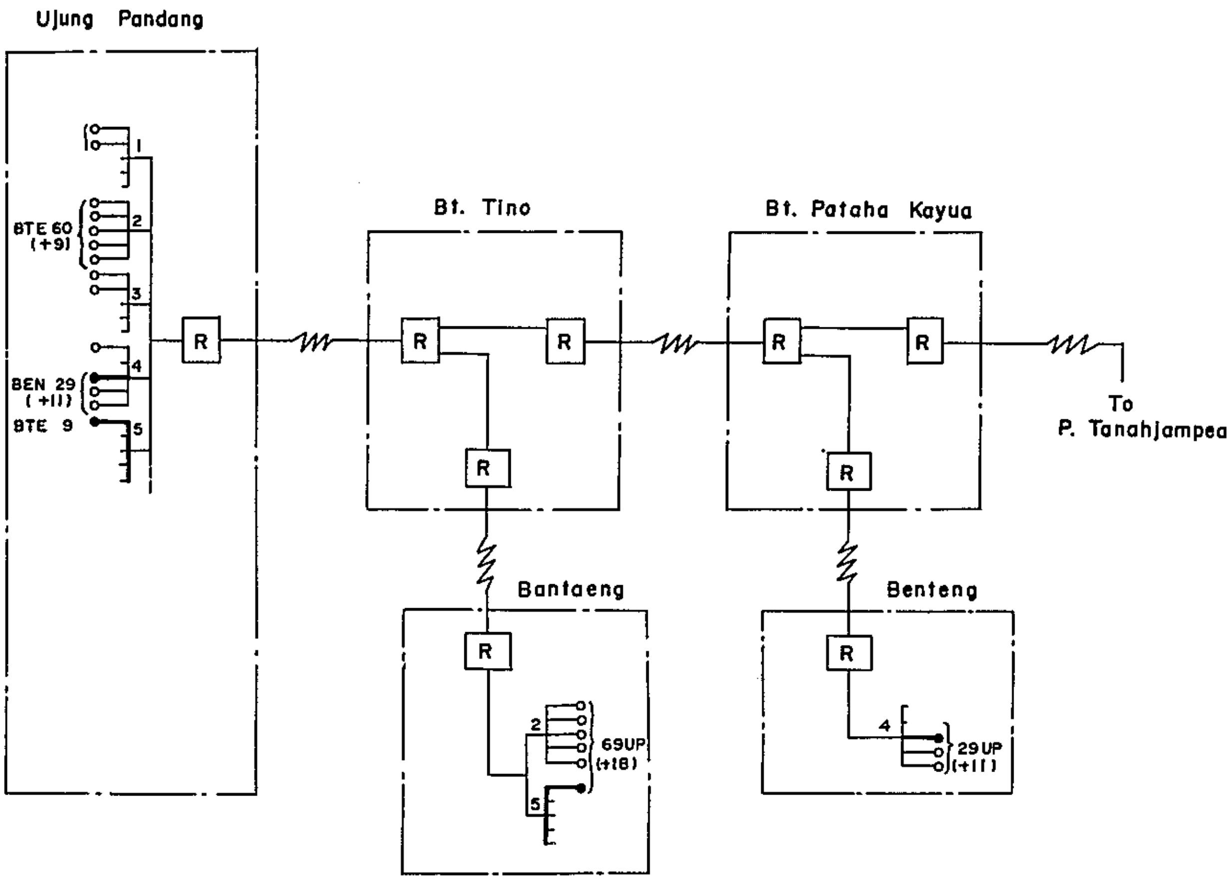


Figure 5-2 (6/6) Channel Accommodation Plan on Intermediate Stage

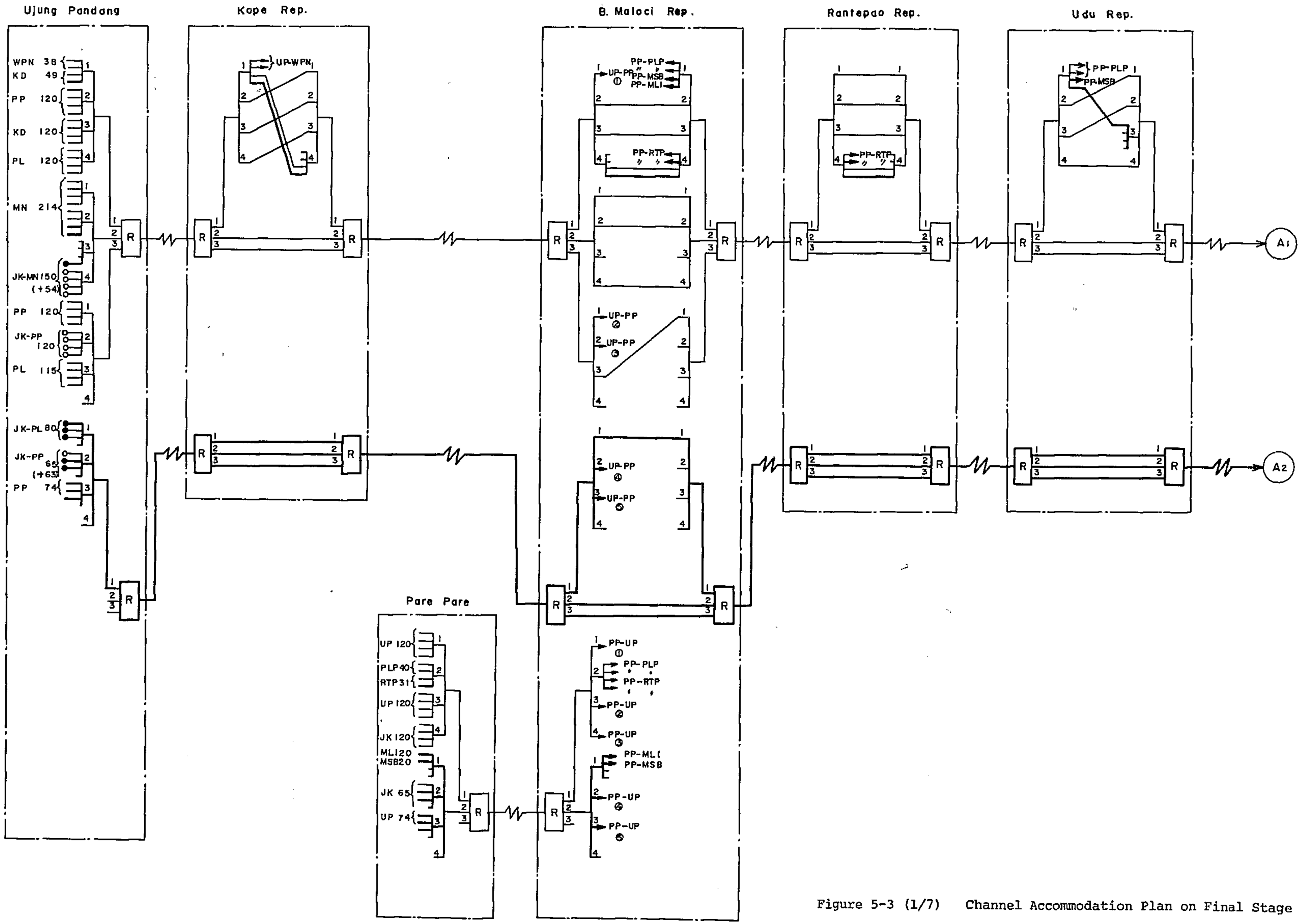


Figure 5-3 (1/7) Channel Accommodation Plan on Final Stage

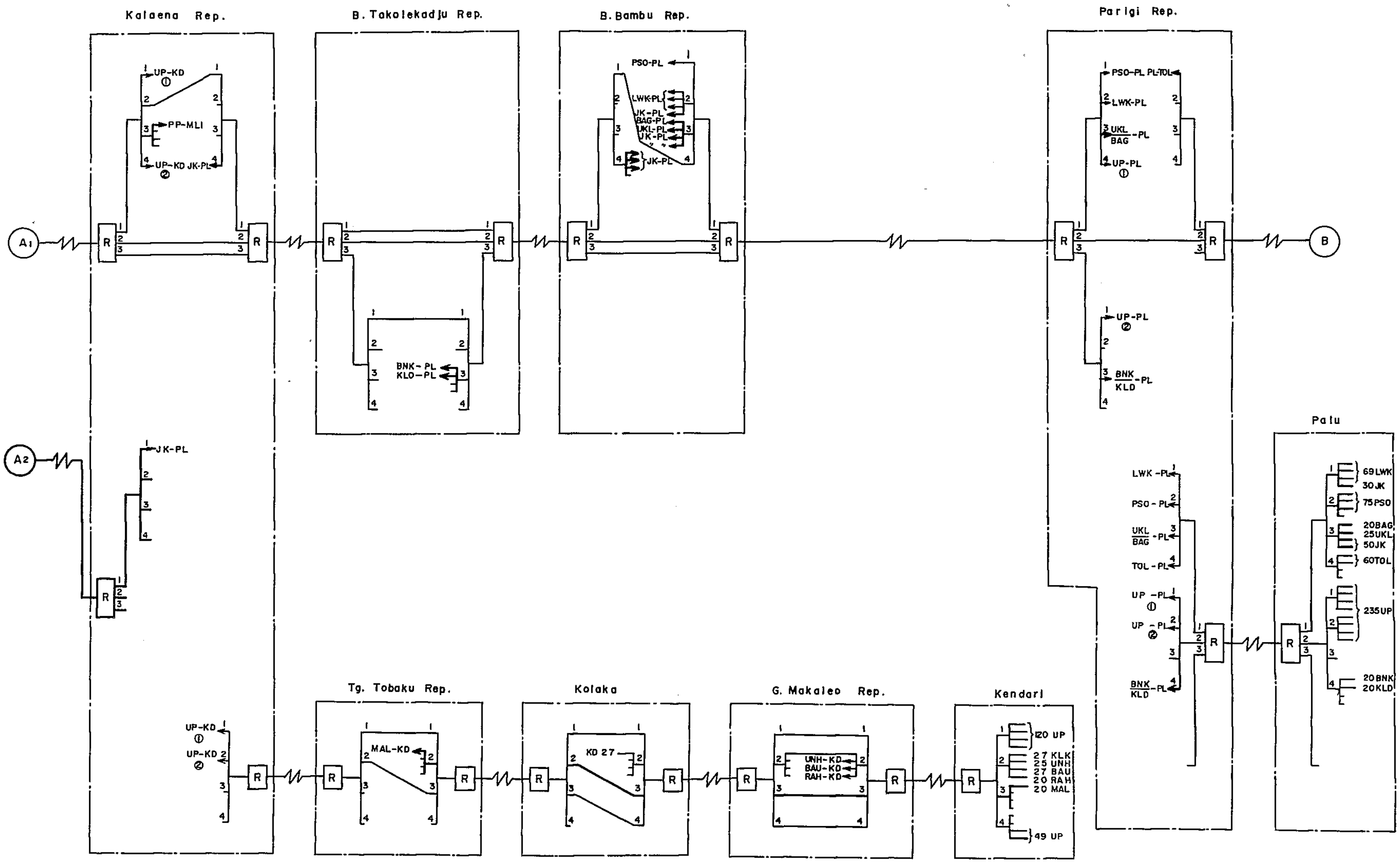


Figure 5-3 (2/7) Channel Accommodation Plan on Final Stage

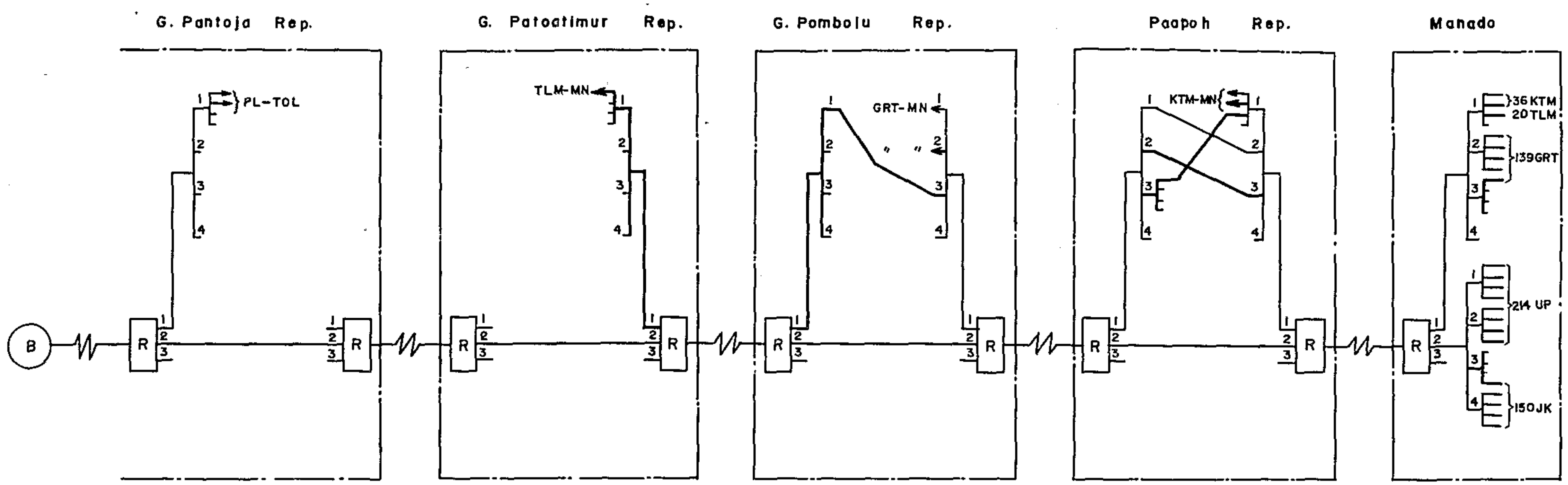


Figure 5-3 (3/7) Channel Accommodation Plan on Final Stage

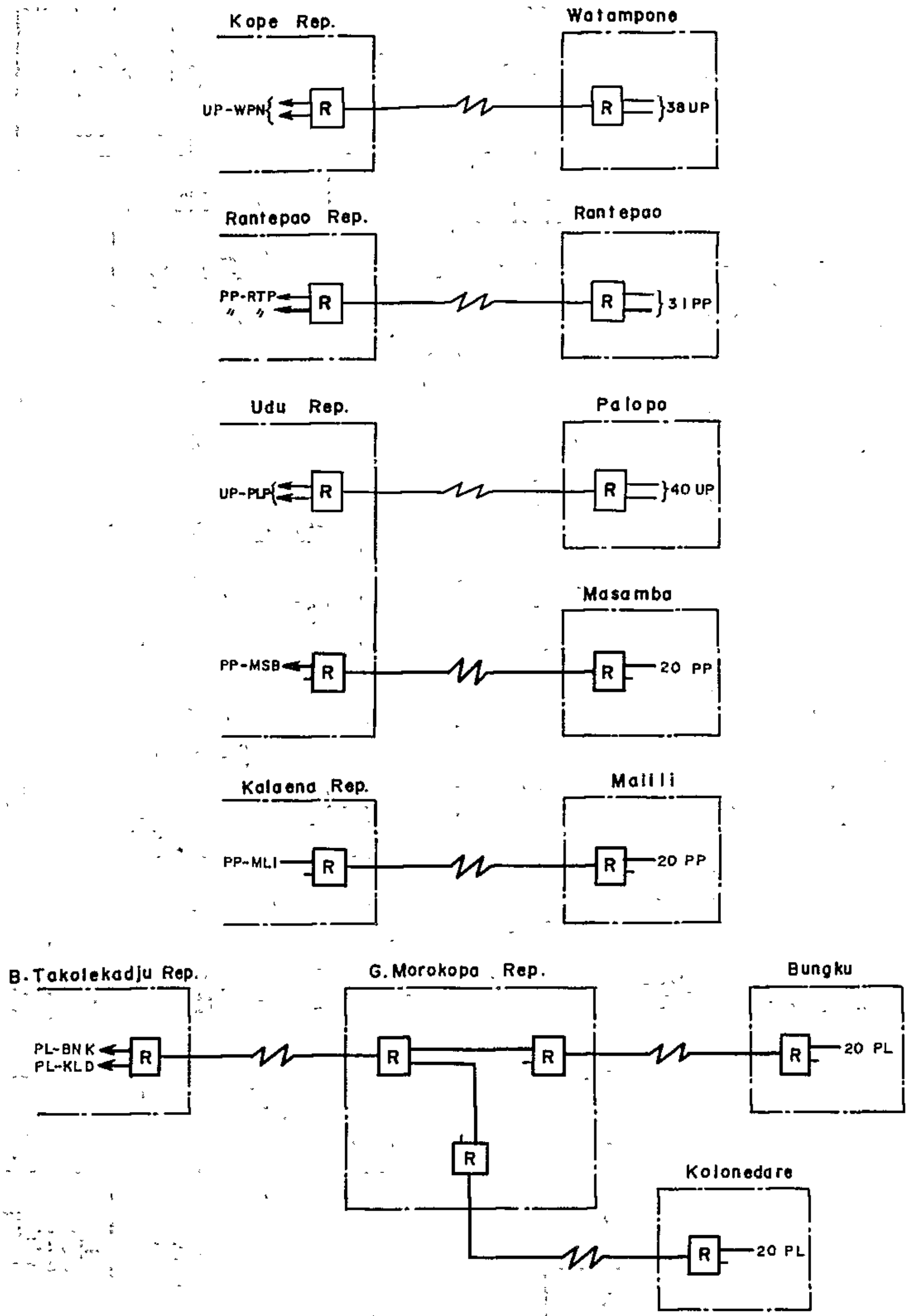


Figure 5-3 (4/7) Channel Accommodation Plan on Final Stage

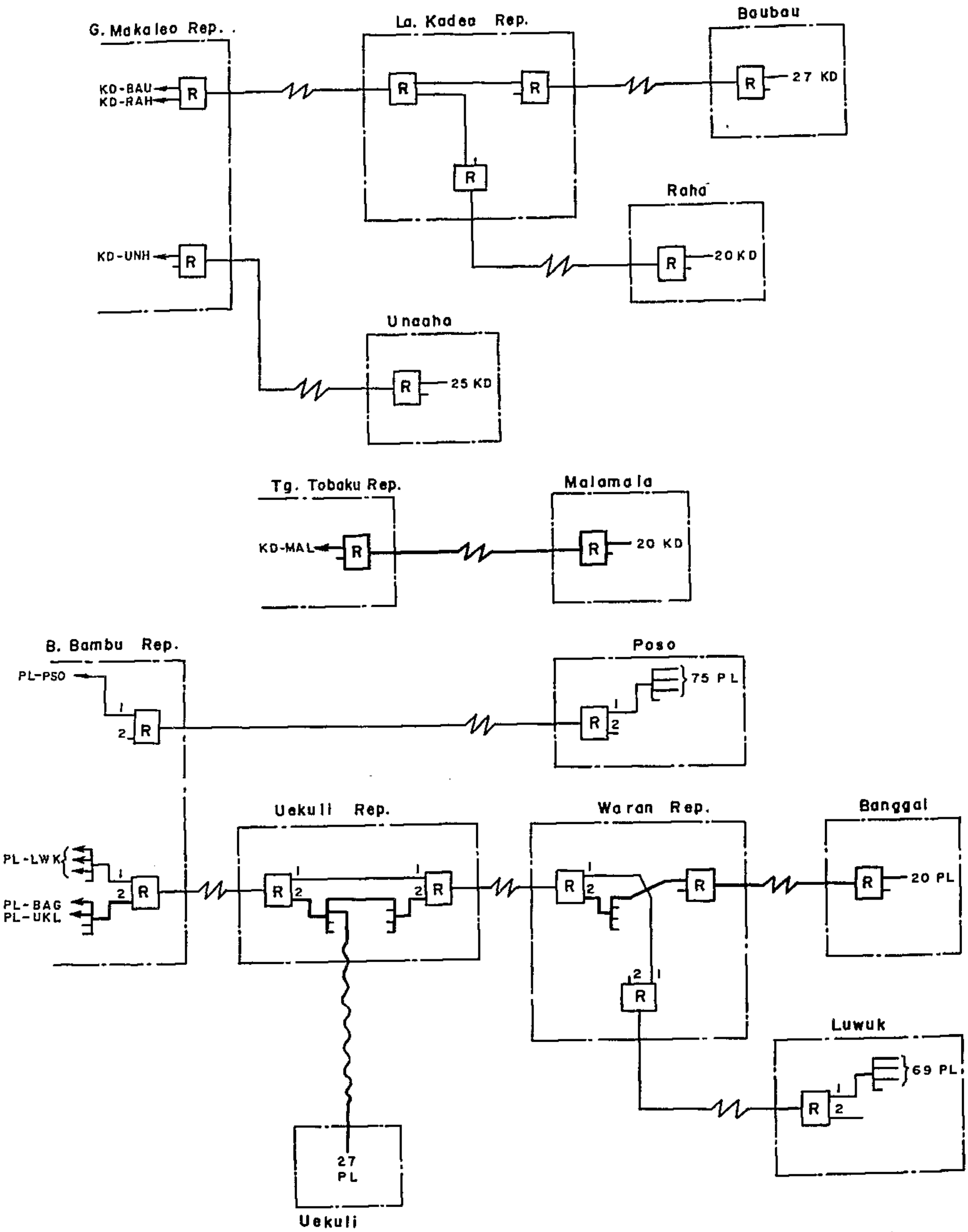


Figure 5-3 (5/7) Channel Accommodation Plan on Final Stage

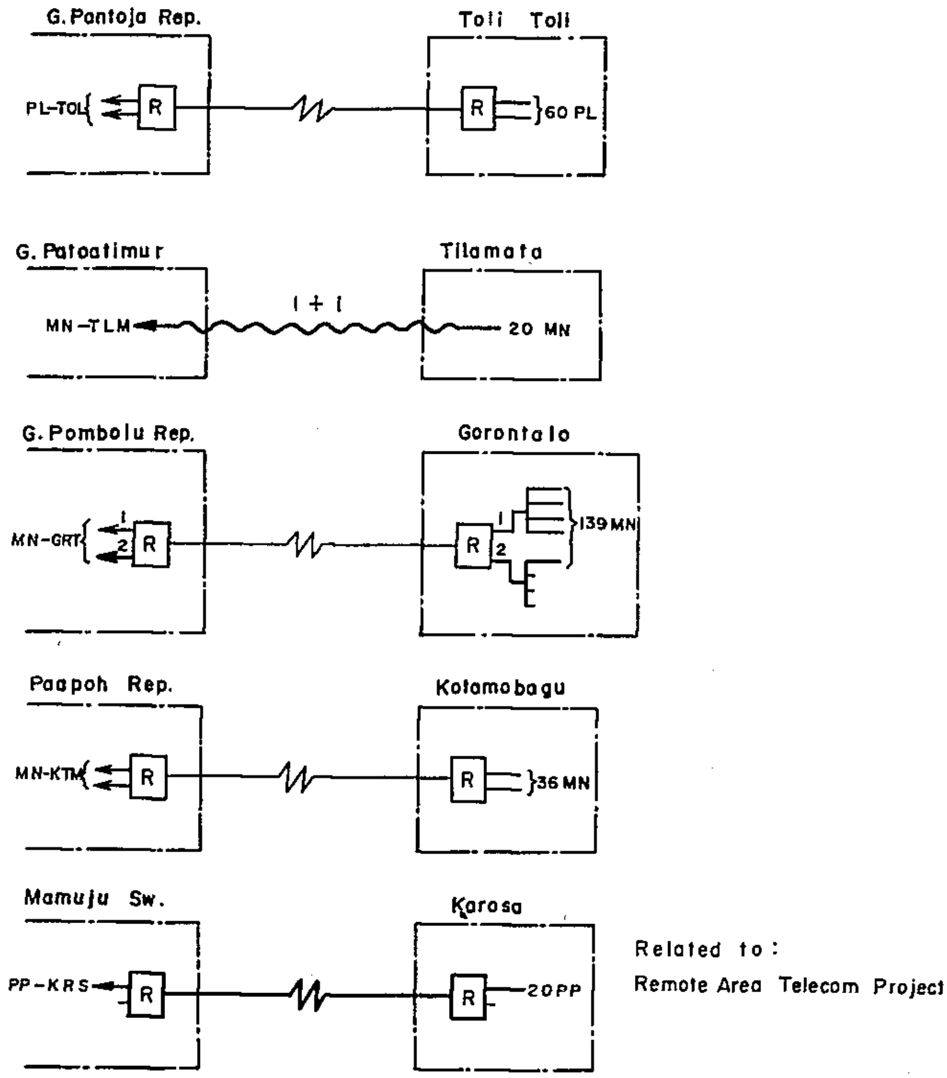


Figure 5-3 (6/7) Channel Accommodation Plan on Final Stage

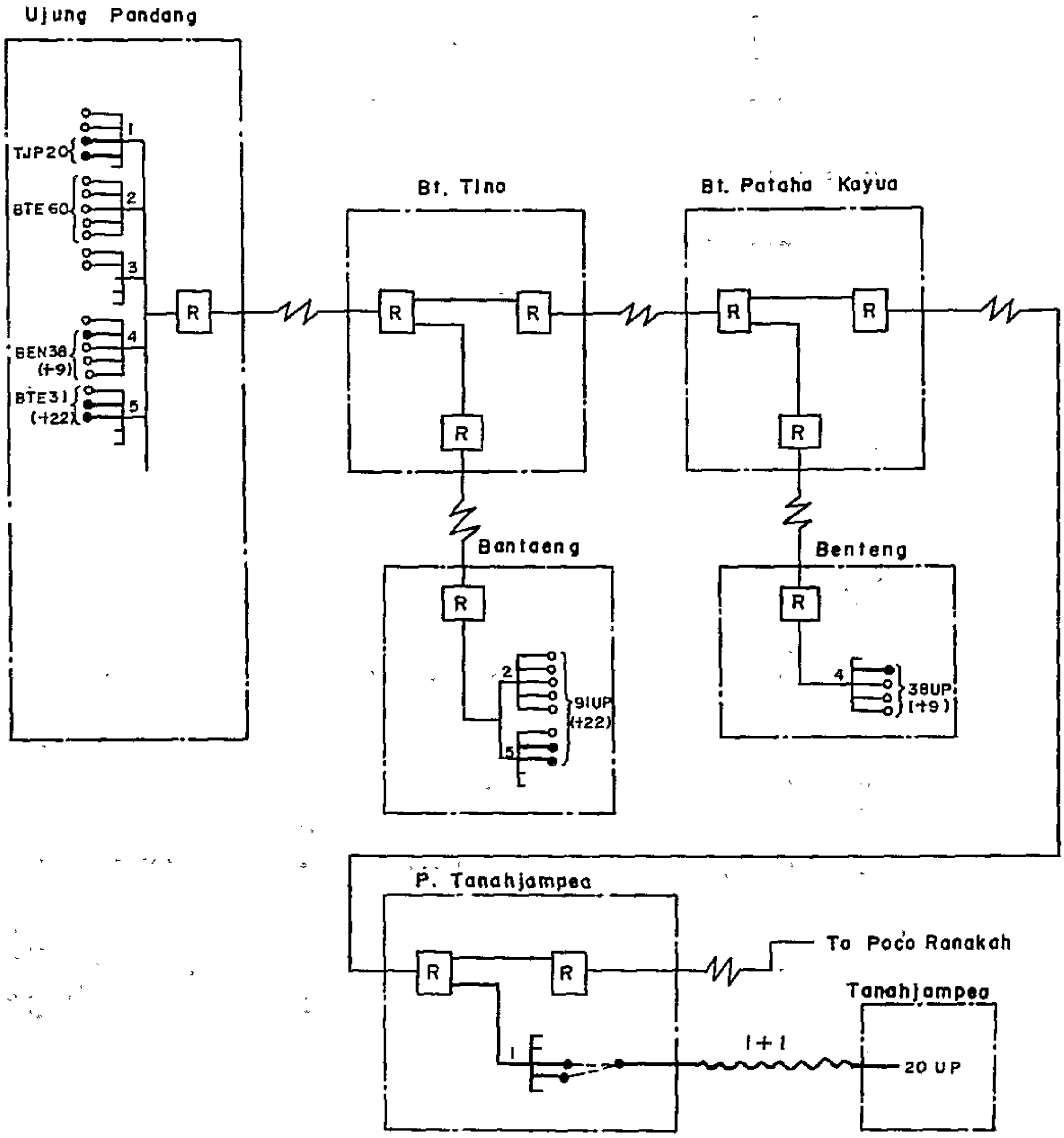


Figure 5-3 (7/7) Channel Accommodation Plan on Final Stage

5-4. Radio System Design

5-4-1 Frequency Plan

(1) For 6 GHz (upper band) and 2 GHz systems to constitute radio transmission routes of this Project, RF channel arrangement as per CCIR Rec. 384-2 and 283-3 is to apply. This channel arrangement is illustrated in Figure 5-4.

(2) RF channels required for main and spur routes of this Project number three and two, respectively. Frequency allocation should be so determined that as many RF channels as antenna system capacity admits can be obtained. In other words, if the number of RF channels commensurate with antenna system capacity can be secured at the beginning, it becomes easy to meet unexpected demand growth or to cater for demand for new telecommunication services.

In this Project, common transmit-receive antenna with capacity for four 6 GHz RF channels and three 2 GHz RF channels is used.

(3) RF bands to be used in this Project are the same as those of Eastern Microwave System, approach link of PALAPA system, as well as radio system of Remote Area Telecommunication Network Project now being planned. Therefore, at the time of project implementation, in-depth study about section by section RF channel allocation must be made so that frequency interference to/from other radio systems can be avoided.

5-4-2 System Performance Objectives

Digital radio system performance is evaluated by percentage of time which exceeds Bit Error Rate (BER) objective. CCIR Rec. AA/9 and Rep. 378-3 provide two, i.e., low and high, BER objectives applicable to hypothetical reference digital path for radio relay systems and real digital path.

(1) Hypothetical Reference Digital Path for Radio Relay Systems (CCIR Rec. AA/9)

a) Low BER Objective

BER should not exceed 1×10^{-7} for more than 1% of any month. As for BER measuring time duration, study is now being made and one minute is proposed for measuring time duration.

b) High BER Objective

BER should not exceed 1×10^{-3} for more than 0.05% of any month.

(2) Real Digital Path (CCIR Rep. 378-3)

For high BER objective, it will be appropriate to distribute by distance the allowable percentage of time only. For low BER objective, it will be appropriate to distribute not only percentage of time but desirable BER value (1×10^{-7} or less) also by statistical method.

In this Project, digital radio system constitution differs from hypothetical reference digital path for radio relay systems. Therefore, objectives given in CCIR Rep. 378-3 are used, this time.

5-4-3 Adoption of Space Diversity and Automatic Equalizer

In digital radio system, fading that takes place on propagation path causes received signal power to deteriorate and in-band amplitude to disperse. These are main causes of system performance failure to exceed low BER objective (outage objective).

In 2 GHz and 6 GHz systems to be used in this Project, fading attributalbe to propagation attenuation due to rainfall can be practically ignored. Main type of fading, this time, is frequency selective fading due to multipath interference.

In such sections where 6 GHz 1,440 CH (34 Mbit/s x 3) system of large transmission capacity is adopted and where reflected waves from sea and ground surfaces exist, in-band amplitude dispersion arises, causing outage to increase drastically. Hence the need for using automatic equalizers and to apply space diversity.

Projected transmission route, this time, is the result of desk study using topographic map of 1/250,000 scale, adjusted by findings in summary field survey. In-depth study of radio propagation path, such as investigation of obstacles, reflection points, etc., on the path, has not yet been carried out.

Radio propagation path in many sections in this Project are located close by coast line, and their path height is relatively low. Therefore, transmission performance deterioration due to fading is anticipated.

Consequently, decision is made to apply space diversity in sections, each with distance of 45 km or more, where 6 GHz system is adopted, and in sections, each with distance of 60 km or more, where 2 GHz system is adopted. Also, in sections where transmission performance may deteriorate drastically due to reflected waves from ground surface, space diversity is to be applied.

5-4-4 Radio Propagation Path and Tower

(1) Radio Propagation Path

Projected transmission route, this time, proceeds along Trans-Sulawesi Highway and other existing main roads. Many radio propagation path sections are littoral or oversea sections. Transmission route shown in Figure 3-1 is selected in due consideration of radio propagation characteristics. Path profile maps of radio repeater sections are given in ANNEX 3.

(2) Tower

This time, antenna height in each radio path section is considered by the following conditions:

a) Path clearance factor be 1 or more at $K^* = 4/3$ and 0.3 or more at $K^* = 2/3$.
   *: Coefficient of effective radius of the earth.

b) Height of thickly grown trees on radio path is assumed to be 25 m, and height of structures in urban sectors is assumed to be 30 m.

Based on the above conditions and antenna height allowance, minimum tower heights are assumed as follows:

- At stations located in urban sector and on flat land................................50 m

- At stations located in mountainous ....40 m

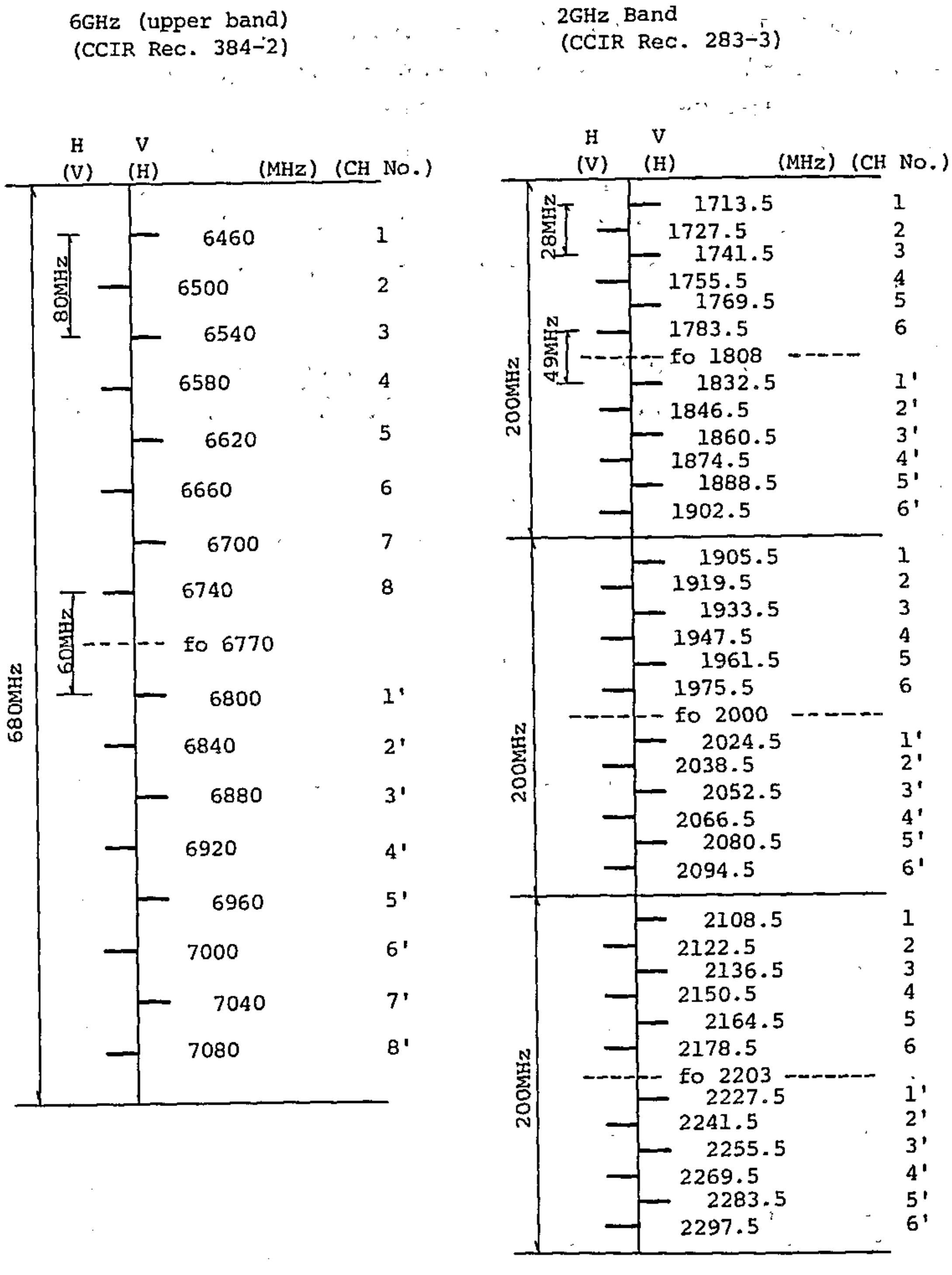


Figure 5-4 Radio Frequency Channel Arrangement Plan for 6GHz (upper band) and 2GHz bands.

5-5. Transmission Loss Distribution Plan

In this Project, digital transmission facilities are to be introduced in existing analog network. Therefore, it is not desirable to apply transmission loss distribution plan based on analog transmission system to this Project.

Statistical data about existing analog transmission system are not available, so that, in transmission loss distribution plan determined this time, CCITT recommended values are used.

Most part of toll switching equipment to be introduced in Sulawesi area from now forward will be digital type equipment. Existing analog equipment, whose service life is about to terminate, will be replaced with digital type equipment. Thus, in the future, telephone network in Sulawesi area will be full digital network.

Temporary transmission loss distribution plan for transition period before network digitalization and the corresponding plan as of time of full network digitalization appear in Figure 5-5 through Figure 5-7.

In-depth study about transmission loss distribution plan is made in ANNEX 5.

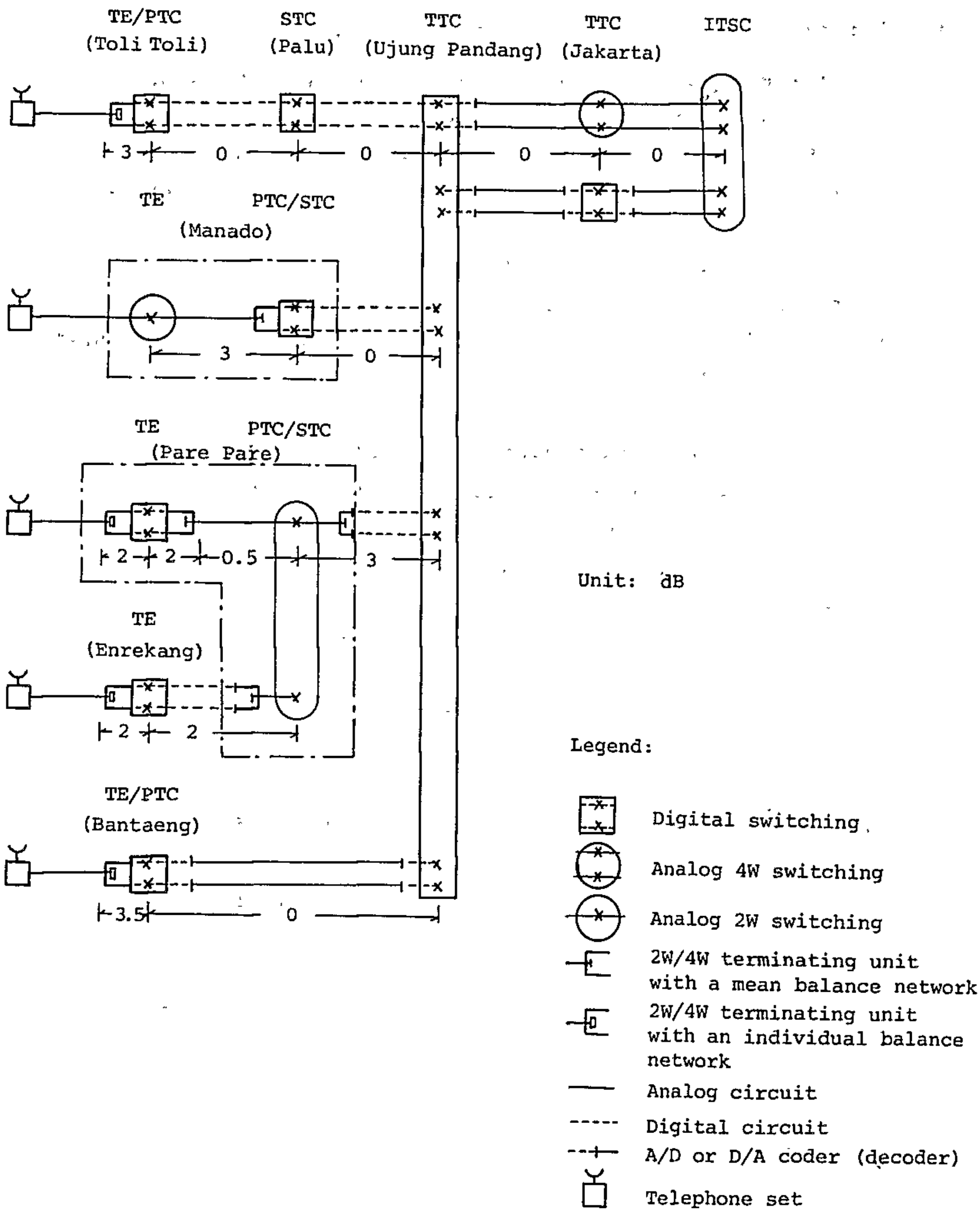


Figure 5-5 Transmission Loss Distribution Plan
(Initial Stage)

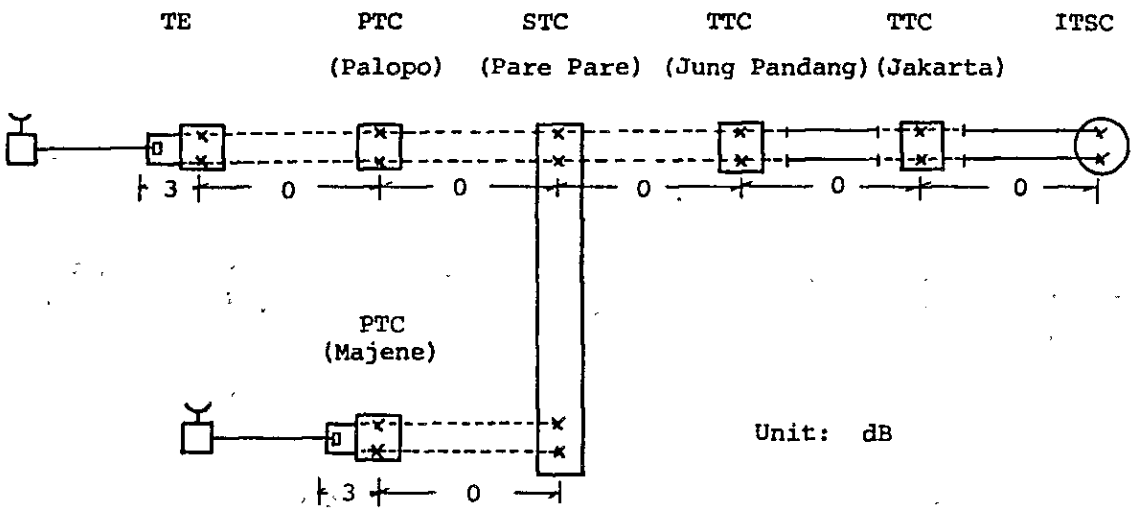


Figure 5-6 Transmission Loss Distribution Plan
(Intermediate Stage)

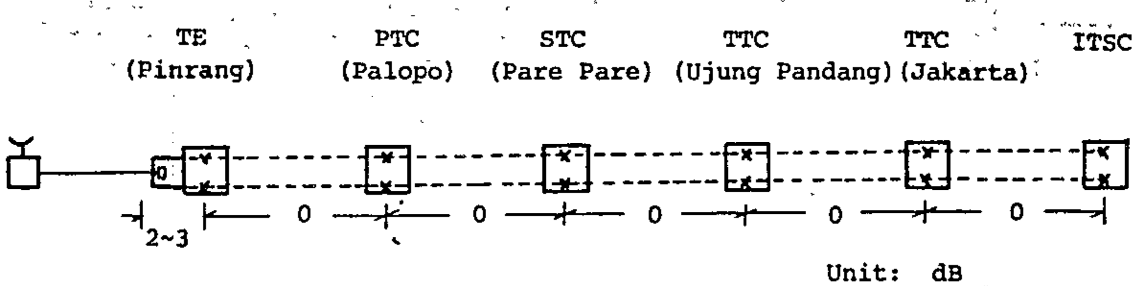


Figure 5-7 Transmission Loss Distribution Plan (Final Stage)

5-6. Interface

Terrestrial transmission system interface conditions are as follows:

(1) Between digital radio system and digital switching system: CCITT recommended 2,048 kbit/s interface.

(2) Between digital radio system and analog switching system: Interface by voice frequency.

(3) Between digital radio system and analog radio system: Interface by voice frequency.

5-7. Outline of Main Equipments

Main equipments proposed in this Project are introduced in outline below.

5-7-1 Radio Equipment

Radio equipment consists of transmitter-receiver unit, antenna, system switchover equipment, and remote supervisory and control equipment. Typical radio repeater and radio terminal system composition appears in Figure 5-8.

PCM signal from digital multiplex equipment, proceeding via system switchover equipment, enters into transmitter-receiver unit and becomes 4-phase (or 8-phase) phase-modulated signal, which then is transmitted from antenna. Receiving procedure is contrary to this.

Radio repeater consists of regenerative repeating or IF repeating transmitter-receiver unit and antenna. Regenerative repeating transmitter-receiver unit first demodulates received signal and re-shapes pulse shape, and then modulates signal again and repeats it. IF repeating transmitter-receiver unit only amplifies received signal at IF stage.

System switchover equipment takes care of automatic switchover from working to protection RF channel in case working RF channel meets with fault or suffers fading, and working system fails to operate normally. This equipment further takes care of automatic switchover from protection to working RF channel when latter is relieved of fault and working system returns to normal operation.

As for remote supervision and control of transmission network, Sulawesi area terrestrial transmission network is to be divided into 11 segments, and in each segment the Maintenance Center is to be established (refer to Chapter 6). At each Maintenance Center, remote supervisory and control equipment is to be established, whereby to carry out remote supervision and control of radio stations and transmission system in maintenance area concerned.

Furthermore, at Ujung Pandang, Central Maintenance Management Center is to be established. This Central Maintenance Management Center will carry out centralized supervision of terrestrial transmission network of all Sulawesi.

Main parameters of radio equipment to be adopted are given in Table 5-1.

5-7-2 Multiplex Equipment

Multiplex equipment to be installed in radio terminals, radio repeaters and cable lead-in stations established by this Project comprises the following four classifications:

- Digital multiplex equipment
- PCM multiplex equipment
- 2,048 kbit/s digital repeater
- Frequency division multiplex equipment

(1) Digital Multiplex Equipment

Digital multiplex equipment consists of second order multiplex equipment and third order multiplex equipment, as per CCITT recommendation. Second order multiplex equipment performs multiplexing and de-multiplexing between four primary digital tributaries and a second order digital stream. Third order multiplex equipment performs multiplexing and de-multiplexing between four second order digital tributaries and a third order digital stream.

(2) PCM Multiplex Equipment

PCM multiplex equipment is primary PCM multiplex equipment. This equipment carries out PCM conversion of 30 CH analog voice signal and multiplexes such signal and thereby obtains one digital primary group.

(3) 2,048 kbit/s Digital Repeater

2,048 kbit/s digital repeater performs regenerative repeating of digital primary group signal.

(4) Frequency Division Multiplex Equipment

Frequency division multiplex equipment is analog type multiplex equipment.

5-7-3 Cable Lead-in System

In this Project, cable lead-in system is to be introduced in three sections. In all of them, cable PCM system (bit rate: 2,048 kbit/s; type of cable: symmetric pair cable; laying formula: aerial) is to be adopted.

Cable PCM system construction in all three sections is scheduled to be during REPELITA VI period (April 1994 - March 1999). Therefore, in consideration of technology development level at that time, further study will have to be made to examine whether cable PCM system is really fit or not. Through such study, optimum lead-in system should be chosen.

5-7-4 Power Supply Facilities

Power supply facilities to be exclusively used in this Project are to be newly established, instead of utilizing existing facilities. New power supply facilities should hold capacity large enough to satisfy power requirement, 20 years ahead, of radio equipment, multiplex equipment and collateral equipment to be installed in radio terminal stations and radio repeater stations.

At the time of detail design, further study should be made about advisability of utilizing existing facilities.

(1) Primary Power Supply

Radio terminals are located in urban area so that commercial power supply is available to them. However, commercial power generation in various cities is not necessarily in sufficient volume, so that, to cope with heavy voltage variations due to load variations, automatic voltage regulator is to be installed in radio terminal stations.

At the same time, as remedial measure against commercial power failure or abnormity, standby diesel engine generator equipment is to be installed.

Radio repeater stations are located on mountain-top or away from power transmission and distribution lines. Hence, commercial power supply utilization is difficult. Alternative is to adopt independent power supply system, and, for such independent system, "dual prime mover system" is to be adopted. "Dual prime mover system" is a system that operates two diesel engine generators alternately at prearranged time intervals, and this alternate operation of two generators is from viewpoints of economy and operation/maintenance.

(2) Power Supply to Telecommunication Loads

As means of power supply to telecommunication loads in radio terminal stations and radio repeater stations, charge-discharge system and full floating system can be considered. This time, from viewpoints of economy and operation/maintenance, decision is made to adopt full floating system.

Full floating system advantages as compared with charge-discharge system are as follows:

- Power supply on round-the-clock basis to AC loads at radio repeater station is possible. Such AC loads include air-conditioning system, dehumidifier interior lighting and measuring equipment.
- Batteries of small capacity can be used. In the case of charge-discharge system, the discharge rate must generally be kept to 50% or so in order to prolong battery life. Therefore, large battery capacity is required.
- Battery life is long, i.e., 10 years or even more. In the case of charge-discharge system, battery life is not longer than eight years even if the discharge rate is kept to a level of 50%.

- Rectifier and diesel engine generator of small rated capacity can be used. The reason is that in the case of full floating system, the required battery charging current is small.

- When enclosed type batteries are used, time span before battery electrolyte supplement and specific gravity adjustment become necessary is long. Hence easy maintenance.

As stated in the foregoing, radio terminal stations and radio repeater stations are to have the following power supply facilities installed:

- Radio Terminal Stations

  Primary power supply:
  - Commercial power supply receiving equipment
  - Automatic voltage regulator
  - Standby diesel engine generator equipment

  Power supply to telecommunication loads:
  - Rectifier equipment
  - Lead storage battery

- Radio Repeater Stations

  Primary power supply:
  - Dual prime diesel engine generator equipment

  Power supply to telecommunication loads:
  - Rectifier equipment
  - Lead storage battery

To ensure primary power supply while diesel engine generators are being overhauled and during emergency, mobile power supply equipment is to be retained at each Maintenance Center.

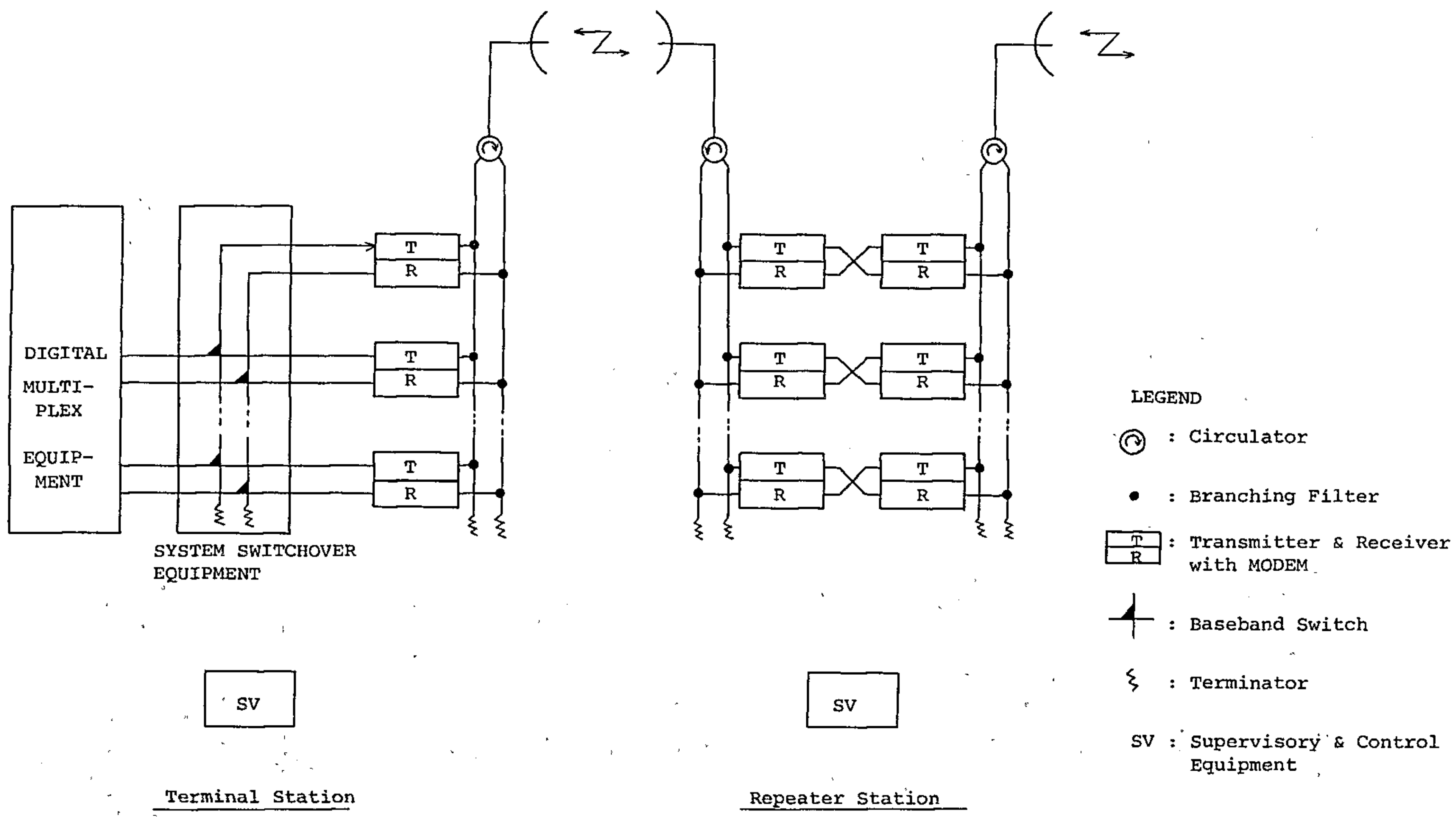


Figure 5-8 Typical Composition of Digital Radio System

Table 5-1 Typical Equipment Parameters of the Selected Digital Radio Systems

1.	Radio frequency band	2 GHz		6 GHz (upper band)	
2.	Transmission Capacity /RF CH				
	. Bit rate (Mbit/s)	2.0 x 2	8.4 x 2	34.4 x 1	34.4 x 3
	. No. of channels in terms of voice channels	60	240	480	1,440
3.	No. of RF channels (Working + Protection)	2 + 1	2 + 1	3 + 1	3 + 1
4.	Modulation system	4PSK	4PSK	4PSK	8PSK
5.	Demodulation system	Coherent detection		Coherent detection	
6.	Repeating system	Regenerative or Heterodyne		Same as at left	
7.	Transmitter output (dBm)	27/23	30/20	30/26/23	30/26/23
8.	Antenna gain (dB)				
	3.6 mø parabolic ant.	35.0		45.5	
	3.0 "	33.4		44.0	
	2.4 "	31.4		42.0	
	1.8 "	28.9		39.5	
9.	Feeder loss (dB) Elliptical feeder	0.044 dB/m		0.071 dB/m	

5-8. Station Buildings

Station buildings to be used in this Project are of the following three categories:

- Buildings for radio terminals
- Buildings for radio repeaters
- Buildings for cable PCM lead-in stations

Comments on these buildings follow:

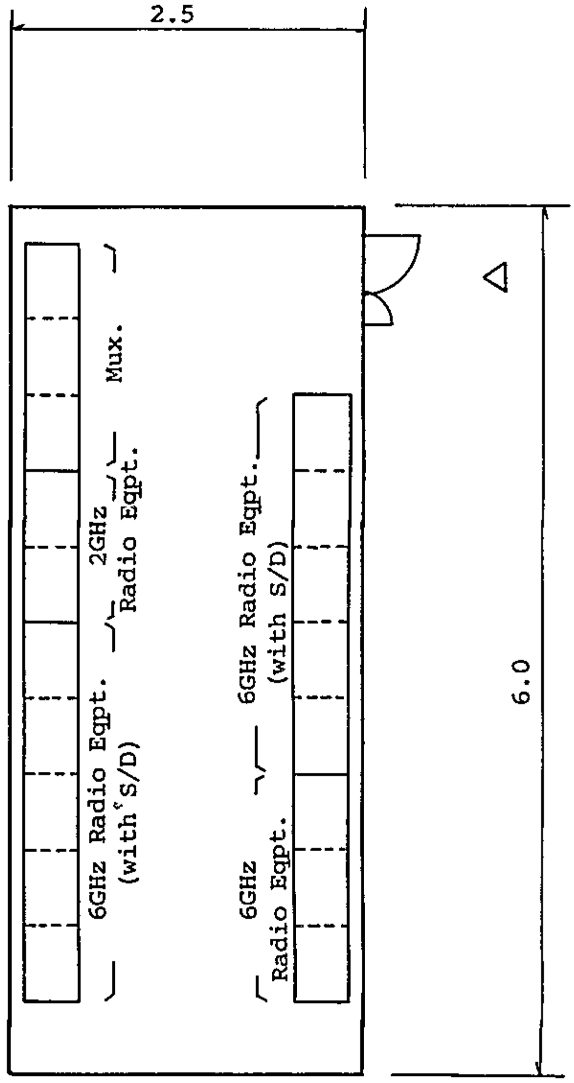
(1) In all buildings for radio terminals, the same floor space should apply to equipment room where to install radio equipment, multiplex equipment and so forth.
That is to say:

- Installation space for radio equipment and multiplex equipment..............5 x 6 m

- Installation space for power supply equipment............................5 x 9 m

(2) Buildings for radio repeaters are to be shelter type buildings. Typical equipment floor layout of radio repeater station (shelter type) is illustrated in Figure 5-9.

(3) For each cable PCM lead-in station building, required floor space is extremely small, so that just one corner of telephone exchange office concerned is enough. Hence, this item is not considered in construction cost estimate.



Unit: m

Figure 5-9 Typical Equipment Floor Layout of Radio Repeater Station (Shelter Type)

6. PRESERVATION WORK

6. Preservation Work

6-1. Maintenance

Telecommunication services perform the role of nerve center for social and economic activities of any country. Because of their so great importance, telecommunication services can never be interrupted even momentarily. Telephone calls exist day and night; therefore, the personnel in charge of telephone service must assume duty on around the clock basis.

In order that the transmission system for telecommunication services can operate as it ought, the well founded operational organization must first be established. Usually, the operational organization consists of major radio repeater or terminal stations on the transmission route operating as attended stations having unattended minor stations under their respective controls.

However, transmission/radio equipment is generally so designed and manufactured as will operate unattended with high enough reliability. Therefore, in this Project, radio repeater and terminal stations will be used as unattended stations, in principle.

Terrestrial transmission network proposed in this Project is a long distance, large scale system to cover the whole Sulawesi area. The entire terrestrial transmission network will be divided into 11 sections and at each key point the supervisory and maintenance organization to control unattended stations (Maintenance Center) will be established. The center will be staffed with permanent maintenance personnel.

The proposed terrestrial transmission network, inclusive of Remote Area Telecommunication Project, will connect all 32 Tertiary, Secondary and Primary Centers in Sulawesi. The network will be further extended to outside of Sulawesi, via existing Eastern Microwave System or Domestic Communication Satellite System, from Ujung Pandang.

Ujung Pandang, itself a Tertiary Center, will become the most important station in the network, where long distance toll telephone circuits to outside of Sulawesi will be concentrated and, at the same time, distributed to all exchanges inside Sulawesi. Hence, at Ujung Pandang, the organization for maintenance and operation of all terrestrial transmission systems in Sulawesi (Central Maintenance Management Center) will be established. There, the required staff will be kept on duty.

PERUMTEL's WITEL-X organization is charted in Figure 6-1 and staff personnel classification in Table 6-1. With the completion of this Project, a new maintenance organization will have to be established in WITEL-X.

When this Project has been realized, the presently operating HF telecommunication system will be used as a backup system. Therefore, the HF system maintenance staff will have to be re-trained so that they can take care of maintenance and operation of the terrestrial transmission network envisaged in this Project.

Following is the proposal concerning the duty lines and staff personnel of "Central Maintenance Management Center" and "Maintenance Center" referred to above. Meanwhile, the bold line section in Figure 6-1 indicates those new centers as incorporated in the existing maintenance organization.

6-1-1 Central Maintenance Management Center

Central Maintenance Management Center will be established in Ujung Pandang Tertiary Center. This Maintenance Center will manage the operation of 11 Maintenance Centers in Sulawesi. At the same time, it will take care of periodical tests and inspections of all terrestrial transmission systems operating in Sulawesi.

The proposed staff personnel lineup follows:

Chief	(Grade: III)	1 person
Sub-Chief	(Grade: II)	1 person
Radio Engineers	(Grade: II)	*6 persons
Mux. Engineers	(Grade: II)	*6 persons
Power Engineers	(Grade: II)	*6 persons
Total		20 persons

* Note: 6 persons are (2 persons x 3 rotations).

6-1-2 Maintenance Center

A total of 11 Maintenance Centers will be established. Each will take care of one out of 11 blocks, into which the whole Sulawesi area will be divided.

The 11 Maintenance Centers are:

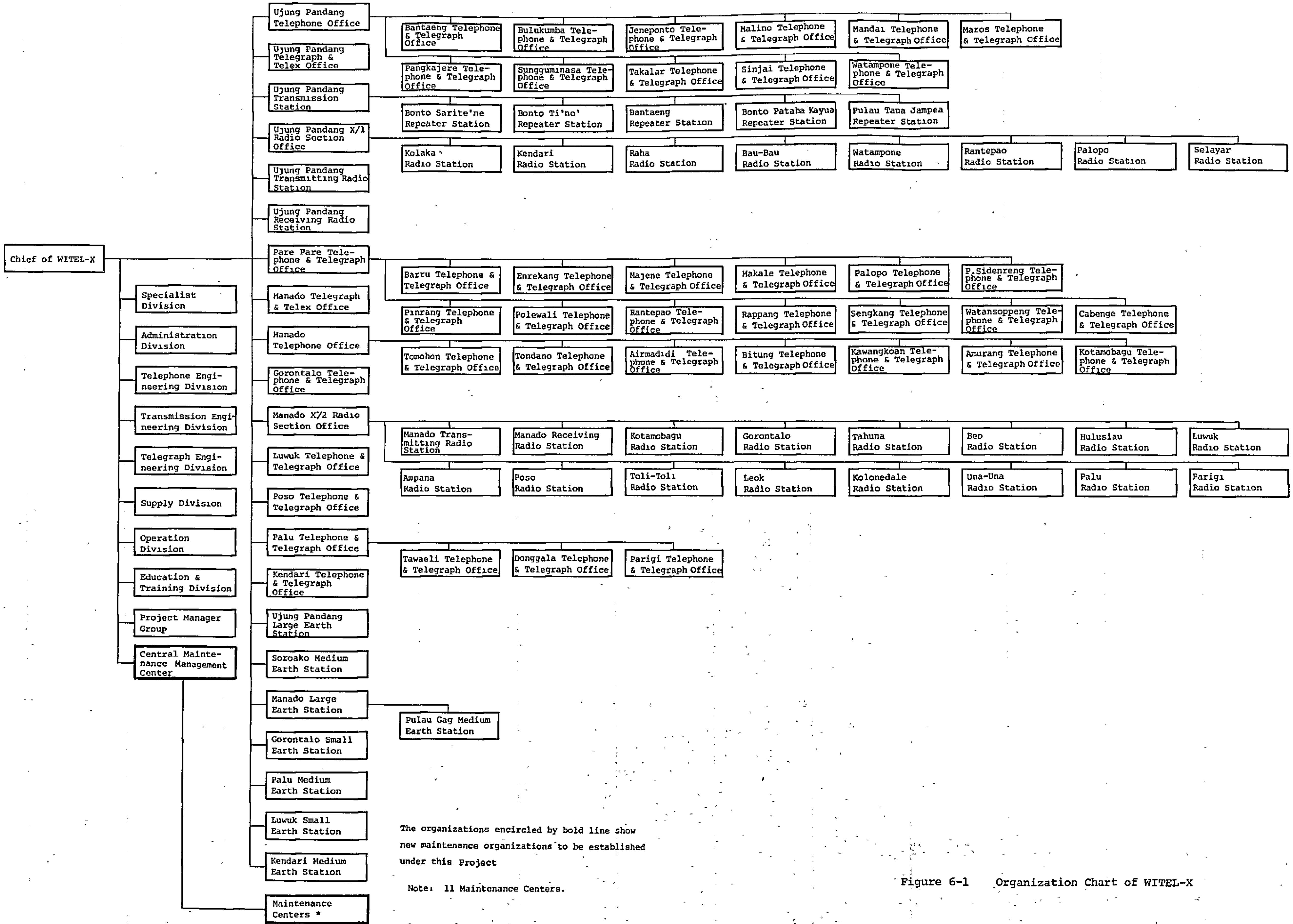
Ujung Pandang Maintenance Center	
Pare Pare	"
Palopo	"
Poso	"
Palu	"
Toli Toli	"
Gorontalo	"
Manado	"
Kendari	"
Kolonedare	"
Luwuk	"

Each Maintenance Center will be assigned to supervisory and maintenance duty toward radio terminal stations, radio repeater stations and cable leading-in stations, and, at the same time, will assist the Central Maintenance Management Center in its duty performance.

The proposed staff personnel lineup of each Maintenance Center follows:

Chief	(Grade: III)	1 person
Radio Engineers	(Grade: II)	*3 persons
Mux. Engineers	(Grade: II)	*3 persons
Power Engineers	(Grade: II)	*3 persons
Total		10 persons
(All Centers		110 persons)

* Note: 3 persons are (1 person x 3 rotations).



The organizations encircled by bold line show new maintenance organizations to be established under this Project

Note: 11 Maintenance Centers.

Figure 6-1 Organization Chart of WITEL-X

Table 6-1 Number of Staffs of WITEL-X

Grade / Year	I	II	III	IV	Total
1976	1,095	369	48	1	1,513
1977	1,153	381	35	1	1,570
1978	1,189	409	34	1	1,633
1979	1,113	466	36	1	1,616
1980	1,071	563	38	1	1,673
1981	1,116	534	39	1	1,690
1982 (Jan.)	1,116	534	39	1	1,690

6-2. Measuring Equipment, Maintenance Supplies, Maintenance Vehicles

Proposal is made that measuring equipment, which will be used frequently, be distributed to each Maintenance Center and each field station, and that measuring equipment, which will not be used frequently, be kept in centralized storage at Central Maintenance Management Center.

For maintenance tools and spare panels/parts, it is proposed that as many as possible be kept in store at each Maintenance Center. Storage at field stations should be limited to the necessary minimum of consumables. Such spare panels/parts that cost much and are needed in small quantities should be kept in store at Central Maintenance Management Center.

Distribution of maintenance vehicles should be in the following number:

Central Maintenance Management Center	4
Each Maintenance Center	2

6-3. Training

Proposed to be constructed by this Project is the digital transmission network, so that its maintenance is difficult for engineers whose knowledge and capability are based on conventional analog technology.

Training of those engineers about new digital technology should be undertaken by the digital equipment suppliers. It is recommended that in-factory training by the equipment supplier be administered for two months to about one half of staff personnel of Central Maintenance Management Center and each Maintenance Center, and on the job training during one year period after the system commissioning. At the same time, instructor training should also be carried out for several qualified personnel.

In this connection, it is proposed that the provision on training be included in the contract provisions for implementation of this Project.

7. CONSTRUCTION COST

7. Construction Cost

Construction cost estimates for implementation of this Project are shown below. Further breakdown appears in Table 7-1, Table 7-2 and Table 7-3.

Unit: Million Yen
(Million Rupiahs)

	Foreign Currency Portion	Local Currency Portion	Total
Initial stage cost	15,177 (37,098)	12,808 (31,309)	27,985 (68,407)
Intermediate stage cost	1,203 (2,940)	1,082 (2,645)	2,285 (5,585)
Final stage cost	2,730 (6,673)	1,656 (4,048)	4,386 (10,721)
Total	19,110 (46,711)	15,546 (38,002)	34,656 (84,713)

Note: The amount quoted above does not include contingency.

Reference: Exchange rate = Rp.660/¥270/US$, as of the middle of October, 1982.

Construction cost estimates appearing above are based on the following conditions:

(1) The whole construction work be divided into three stages, i.e., initial stage work (inside REPELITA IV), intermediate stage work (inside REPELITA V) and final stage work (inside REPELITA VI).

(2) Initial stage work be executed by the Contractor, based on detail design and specifications made by the Consultant and in accordance with his work management plan. However, in intermediate and final stage works, the Consultant will not take part.

(3) Construction work contract be on turn-key basis.

(4) Radio terminal stations be established in telephone exchange buildings, and station construction cost be commensurate with floor space required.
Radio repeater station buildings be the shelter type.

(5) For non-telephone service system, transmission facilities cost only be estimated. This means that data transmission related equipment, e.g., equipment for data channel branching/insertion from/to digital primary group, is excluded from the scope of equipment to be handled in this Project.

(6) All costs be estimated on price level as of 1984.

(7) Construction work fund be disbursed by local currency or foreign currency according to work items concerned. The breakdown follows:

a) Work items to be financed by foreign currency budget

- Radio equipment, remote supervisory and control equipment, multiplex equipment, power supply system and antenna system
- Antenna towers
- Shelters for radio repeater
- Measuring equipment and spares
- Overseas transportation and insurance
- Part of tower erection and tower foundation work
- Part of equipment installation and adjustment by test
- Training (in-factory training, at-site training)
- Consultant services

b) Work items to be financed by local currency budget

- Site land ground levelling
- Building construction
  (for radio terminal stations only)
- Access road construction
- Domestic transportation and insurance
- Part of tower erection and tower foundation work
- Part of equipment installation and adjustment by test
- Maintenance vehicles
- Consultant services

Table 7-1 Construction Cost in the Initial Stage

Unit: Million Rupiah

Item	Cost			Remarks
	Foreign Currency	Local Currency	Total	
I. Equipment				
(1) Radio Transmission System	8,597	-	8,597	Including SV and MUX
(2) Cable Lead-in System	-	-	-	
(3) Power Supply System	4,676	-	4,676	Including mobile type engine generators
(4) Antenna Tower	4,564	-	4,564	
(5) Equipment Shelter	4,065	-	4,065	
(6) Test Equipment, Spares	1,657	-	1,657	Including tools and handbooks
(7) Installation Materials	430	-	430	
Sub-total of (1) ∿ (7) (FOB)	23,989	-	23,989	
(8) Freight and Insurance	1,679	-	1,679	
Sub-total of (1) ∿ (8)	25,668	-	25,668	
II. Installation and Engineering				
(9) Installation & Engineering Fee	8,086	11,731	19,817	
(10) Training	902	-	902	
(11) One Year Maintenance Assistance	472	-	472	
Sub-total of (9) ∿ (11)	9,460	11,731	21,191	
Sub-total of I and II	35,128	11,731	46,859	
III. Civil Works and Others				Not including land acquisition. Including site levelling.
(12) Access Roads	-	18,072	18,072	
(13) Buildings	-	274	274	
(14) Fuel Tanks	-	352	352	
(15) Maintenance Vehicles	-	174	174	
Sub-total of (12) ∿ (15)	-	18,872	18,872	
Total of I, II and III	35,128	30,603	65,731	
IV. Consulting Services				
(16) Consulting Service Fee	1,970	706	2,676	
Grand Total	37,098	31,309	68,407	
V. Contingency	3,710	3,131	6,841	
Grand Total & Contingency	40,808	34,440	75,248	

Reference: Exchange Rate = Rp.660/¥270/US$

Table 7-2 Construction Cost in the Intermediate Stage

Unit: Million Rupiah

Item	Cost			Remarks
	Foreign Currency	Local Currency	Total	
I. Equipment				
(1) Radio Transmission System	521	-	521	Including SV and MUX
(2) Cable Lead-in System	-	-	-	
(3) Power Supply System	374	-	374	
(4) Antenna Tower	499	-	499	
(5) Equipment Shelter	266	-	266	
(6) Test Equipment, Spares	129	-	129	Including tools and handbooks
(7) Installation Materials	27	-	27	
Sub-total of (1) ∿ (7) (FOB)	1,816	-	1,816	
(8) Freight and Insurance	127	-	127	
Sub-total of (1) ∿ (8)	1,943	-	1,943	
II. Installation and Engineering				
(9) Installation & Engineering Fee	763	1,233	1,996	
(10) Training	161	-	161	
(11) One Year Maintenance Assistance	73	-	73	
Sub-total of (9) ∿ (11)	997	1,233	2,230	
Sub-total of I and II	2,940	1,233	4,173	
III. Civil Works and Others				
(12) Access Roads	-	1,320	1,320	Not including land acquisition
(13) Buildings	-	68	68	Including site levelling
(14) Fuel Tanks	-	24	24	
(15) Maintenance Vehicles	-	-	-	
Sub-total of (12) ∿ (15)	-	1,413	1,413	
Total of I, II and III	2,940	2,645	5,585	
IV. Consulting Services				
(16) Consulting Service Fee	-	-	-	
Grand Total	2,940	2,645	5,585	
V. Contingency	294	265	559	
Grand Total & Contingency	3,234	2,910	6,144	

Reference: Exchange Rate = Rp.660/¥270/US$

Table 7-3 Construction Cost in the Final Stage

Unit: Million Rupiah

Item	Cost			Remarks
	Foreign Currency	Local Currency	Total	
I. Equipment				
(1) Radio Transmission System	1,428	-	1,428	Including SV and MUX
(2) Cable Lead-in System	64	-	64	
(3) Power Supply System	868	-	868	Including mobile type engine generators
(4) Antenna Tower	1,002	-	1,002	
(5) Equipment Shelter	467	-	467	
(6) Test Equipment, Spares	315	-	315	Including tools and handbooks
(7) Installation Materials	75	-	75	
Sub-total of (1) ∿ (7) (FOB)	4,219	-	4,219	
(8) Freight and Insurance	296	-	296	
Sub-total of (1) ∿ (8)	4,515	-	4,515	
II. Installation and Engineering				
(9) Installation & Engineering Fee	1,606	2,501	4,107	
(10) Training	405	-	405	
(11) One Year Maintenance Assistance	147	-	147	
Sub-total of (9) ∿ (11)	2,158	2,501	4,659	
Sub-total of I and II	6,673	2,501	9,174	
III. Civil Works and Others				
(12) Access Roads	-	1,318	1,318	Not including land acquisition
(13) Buildings	-	171	171	
(14) Fuel Tanks	-	44	44	Including site levelling
(15) Maintenance Vehicles	-	15	15	
Sub-total of (12) ∿ (15)	-	1,547	1,547	
Total of I, II and III	6,673	4,048	10,721	
IV. Consulting Services				
(16) Consulting Service Fee	-	-	-	
Grand Total	6,673	4,048	10,721	
V. Contingency	667	406	1,073	
Grand Total & Contingency	7,340	4,454	11,794	

Reference: Exchange Rate = Rp.660/¥270/US$

8. PROJECT IMPLEMENTATION SCHEDULE

8. Project Implementation Schedule

In this Project, the terrestrial transmission network construction work will be carried out in three stages (initial, intermediate and final), in consideration of the traffic forecast result up to the year 2005.

Implementation schedule appears in Table 8-1.

Table 8-1 Implementation Schedule for Sulawesi Terrestrial Transmission Network Project

Item	Fiscal Year	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Initial Stage Implementation	Procurement of Budget																							
	Selection of Consultant																							
	Detailed Design																							
	Selection of Contractor																							
	Land Procurement, Ground Levelling & Land Formation																							
	Manufacturing, Construction & Installation																							
	Commencement of Service																							
	One-Year Maintenance																							
Intermediate & Final Stages Implementation	Manufacturing, Construction & Installation										(Intermediate Stage)					(Final Stage)								

9. FINANCIAL AND ECONOMIC ANALYSES

9. Financial and Economic Analyses

9-1. Cost

Cost of imlementation of this Project can be divided into three main categories. They are:

- Capital investment cost
- Maintenance and operation cost
- Principal and interest payment cost

The cost estimates and the underlying philosophies are described below.

9-1-1 Capital Investment Cost

Initial, intermediate and final capital investments will be made during REPELITA IV, REPELITA V and REPELITA VI periods, respectively. The three investment cost estimates are given in Tables 7-1, 7-2 and 7-3 of Chapter 7.

For land procurement cost, the following considerations are made:

Radio repeater stations are located on mountain-top and, in most cases, the sites are in state owned estate. For these site lands, no alternative production in a national economic sense is expected for the foreseeable future. Therefore, land procurement cost of this category is set at zero in this Project.

As for radio terminal station sites, their total land requirement is extremely small. Furthermore, the most part of sites can be found in the existing telephone exchange sites. Therefore, land procurement cost of this category is also set at zero.

All kinds of equipment to be used in this Project will have their service life terminated during the life period of this Project. Hence the need for their replacement. Consequently, based on the undermentioned equipment life spans, equipment replacement cost is included in the project cost.

- Telecommunication equipment: 20 years
- Rectifier equipment: 20 years
- Engine generator equipment:

  Dual type .... 8 years
  Standby unit .... 20 years

- Storage batteries: 10 years
- Shelters: 40 years
- Antenna towers: 40 years

Salvage value of each kind of equipment as of the termination of project life is calculated, based on the equipment life span. Such salvage value is appropriated as minus cost as of the time the project life terminates.

9-1-2 Maintenance and Operation Cost

Maintenance and operation cost required of facilities completed by this Project consists of the following cost items:

(1) Personnel Cost

Size of maintenance/operation staff:

Central Maintenance Management Center

20 persons

Maintenance Centers

10 persons x 10 centers
(up to 1997)

10 persons x 11 centers
(from 1998)

General administration staff

20 persons

Personnel cost calculation is based on the number of staff personnel required as above. However, personnel costs of drivers and guardsmen are excluded.

(2) Property Cost

a) Maintenance Supplies Cost

Cost of maintenance/operation supplies (spare panels and parts, etc.) is included in initial capital investment cost to finance purchases of required supplies during the project life period. Therefore, maintenance supplies cost is not appropriated in maintenance and operation cost.

b) Power Cost

Radio terminal stations are to receive commercial power supply from power company. Charges for power consumption are calculated and appropriated as power cost.

Radio repeater stations are to use independent power generation system. Hence no power cost.

c) Engine Fuel and Oil Cost

Dual prime mover system is to be adopted for independent power generation at radio repeater stations. Engine fuel (light oil) and engine oil cost is appropriated on the assumption that dual prime mover system will be operated throughout the project life.

For standby engine generator equipment at radio terminal stations, commercial power availability is unstable. Hence, for the equipment, fuel and oil cost is appropriated on the assumption that the rate of operation is 3 days/month at an average.

d) Maintenance Vehicle Upkeep Cost

Four maintenance vehicles will be distributed to Central Maintenance Management Center and two to each Maintenance Center. For these maintenance vehicles, upkeep cost is appropriated on the assumption that the average daily operation mileage per vehicle is 150 km.

9-1-3 Principal and Interest Payment Cost

Foreign currency requirement for initial capital investment is to be catered for with foreign soft loan. The rest is to be filled with PERUMTEL's own fund.

Terms and conditions applicable to foreign soft loan are to be as follows:

Rate of interest: 3.5% per annum

Repayment period: 30 years including grace period of 10 years. Repayment in equal instalments in the remaining 20 years.

For capital investment cost and maintenance/operation cost calculations by philosophies described in the foregoing paragraphs, year by year breakdown appears in Table 9-1. Table 9-2 presents yearly behaviors of principal and interest payment cost.

Table 9-1 Investment and Operation/Maintenance Cost

Unit: Million Rupiah

Period (Year)	Investment	Operation and Maintenance Cost	Total
1984	667	-	667
1985	10,015	-	10,015
1986	19,108	-	19,108
1987	19,071	-	19,071
1988	19,074	714	19,788
1989	472	714	1,186
1990	-	897	897
1991	-	714	714
1992	2,792	897	3,689
1993	2,793	743	3,536
1994	-	929	929
1995	174	755	929
1996	2,765	743	3,508
1997	5,361	790	6,151
1998	5,681	1,029	6,710
1999	-	858	858
2000	-	1,049	1,049
2001	186	843	1,029
2002	174	1,056	1,230
2003	27	858	885
2004	-	843	843
2005	-2,843	843	-2,000

Table 9-2 Repayment Schedule of Foreign Loan

Unit: Million Rupiah

Period (Year)	Foreign Loan	Cumulative Foreign Loan	Repayment of Foreign Loan	Cumulative Repayment	Balance of Foreign Loan	Interest Payment	Remarks
1984	494	494	-	-	494	17	Foreign Loan Agreement will be signed in 1983.
1985	494	988	-	-	988	34	
1986	7,258	8,246	-	-	8,246	288	
1987	14,190	22,436	-	-	22,436	785	
1988	14,192	36,628	-	-	36,628	1,281	
1989	472	37,100	-	-	37,100	1,298	
1990	-	-	-	-	37,100	1,298	
1991	-	-	-	-	37,100	1,298	
1992	-	-	-	-	37,100	1,298	
1993	-	-	-	-	37,100	1,298	
1994	-	-	1,855	1,855	35,245	1,234	
1995	-	-	1,855	3,710	33,390	1,168	
1996	-	-	1,855	5,565	31,535	1,105	
1997	-	-	1,855	7,420	29,680	1,039	
1998	-	-	1,855	9,275	27,825	973	
1999	-	-	1,855	11,130	25,970	909	
2000	-	-	1,855	12,985	24,115	843	
2001	-	-	1,855	14,840	22,260	780	
2002	-	-	1,855	16,695	20,405	714	
2003	-	-	1,855	18,550	18,550	650	
2004	-	-	1,855	20,405	16,695	584	
2005	-	-	1,855	22,260	14,840	518	
2006	-	-	1,855	24,115	12,985	455	
2007	-	-	1,855	25,970	11,130	389	
2008	-	-	1,855	27,825	9,275	325	
2009	-	-	1,855	29,680	7,420	259	
2010	-	-	1,855	31,535	5,565	196	
2011	-	-	1,855	33,390	3,710	130	
2012	-	-	1,855	35,245	1,855	64	
2013	-	-	1,855	37,100	0	0	

9-2. Revenue

Revenue items to be used in financial analysis of this Project are the following three:

- Installation fee revenue
- Basic fee revenue
- Call charge revenue

Philosophies for item-wise revenue calculations are described below.

9-2-1 Installation Fee Revenue

Telephone and telex installation fee revenue consists of monetary collections from subscribers at the time of equipment installation. Charge on subscribers includes installation cost burden charge.

9-2-2 Basic Fee Revenue

Telephone and telex basic fee revenue consists of periodical payment by subscribers without regard to the number of calls. This periodical payment by subscribers includes the fixed amont portion of call charges by manual exchanges.

9-2-3 Call Charge Revenue

Telephone and telex call charge revenue consists of payment by subscribers in accordance with the number of calls. Call charge revenue is estimated from annual average of calls per subscriber multiplied by additional mean tariff. More precisely:

- Traffic via terrestrial transmission system to be established by this Project is to be converted to annual total call meterings. Formula for this conversion is:

$$M = A \cdot C_1 \cdot C_2 \cdot 3600 \cdot \alpha/P$$

where

M : Annual total call meterings

A : Busy hour traffic (Erl.)

C_1: Reciprocal of busy hour concentration rate

C_2: Annual total operating days

P : Average metering pulse interval

α : Connection complete ratio

- From call meterings obtained by the foregoing formula, call charge revenue can be obtained by the following formula:

$$Y = M \cdot 50^{RP} \cdot Z \cdot X$$

where

Y : Call charge revenue

M : Annual total call meterings

Z : Coefficient of revenue correction by telex and other service

X : Chargeable subscriber ratio

Completion of this Project is bound to arouse telephone and telex call potentials in other area than this Project area. Revenue increment by such induced calls, estimated at 10% of the revenue obtained by the above formula, is added to the revenue.

Operating revenue comprising installation fee revenue, basic fee revenue and call charge revenue calculated by philosophies described in the foregoing paragraphs is given in Table 9-3.

Table 9-3 Operating Revenue

Unit: Million Rupiah

Period (Year)	Operating Revenue
1984	-
1985	-
1986	-
1987	-
1988	3,471
1989	7,003
1990	7,509
1991	8,020
1992	8,531
1993	9,042
1994	9,585
1995	10,450
1996	11,252
1997	12,049
1998	12,846
1999	14,070
2000	15,366
2001	16,610
2002	17,822
2003	19,069
2004	20,313
2005	20,594

9-3. Financial Analysis

Based on costs and benefits obtained as per above, cash flow is formulated. Cash inflow appears in Table 9-4 and cash outflow in Table 9-5. Net cash flow is given in Table 9-6.

Costs and benefits to be used in financial analysis derive from cash flow data.

Internal Financial Rate of Return (IFRR) of this Project calculated by those cash flow data becomes 14.38% as seen in Table 9-7.

IFRR of 14.38% of this Project indicates that this Project is financially feasible.

Table 9-4 Cash Inflow

Unit: Million Rupiah

Period (Year)	Operating Revenue	Foreign Loan	Total Cash Inflow
1984	-	494	494
1985	-	494	494
1986	-	7,258	7,258
1987	-	14,190	14,190
1988	3,471	14,192	17,663
1989	7,003	472	7,475
1990	7,509	-	7,509
1991	8,020	-	8,020
1992	8,531	-	8,531
1993	9,042	-	9,042
1994	9,585	-	9,585
1995	10,450	-	10,450
1996	11,252	-	11,252
1997	12,049	-	12,049
1998	12,846	-	12,846
1999	14,070	-	14,070
2000	15,366	-	15,366
2001	16,610	-	16,610
2002	17,822	-	17,822
2003	19,069	-	19,069
2004	20,313	-	20,313
2005	20,594	-	20,594

Table 9-5 Cash Outflow

Unit: Million Rupiah

Period (Year)	Investment	Operating Expenses	Repayment of Foreign Loan	Interest on Foreign Loan	Total Cash Outflow
1984	667	-	-	17	684
1985	10,015	-	-	34	10,049
1986	19,108	-	-	288	19,396
1987	19,071	-	-	785	19,856
1988	19,074	714	-	1,281	21,069
1989	472	714	-	1,298	2,484
1990	-	897	-	1,298	2,195
1991	-	714	-	1,298	2,012
1992	2,792	897	-	1,298	4,987
1993	2,793	743	-	1,298	4,834
1994	-	929	1,855	1,234	4,018
1995	174	755	1,855	1,168	3,952
1996	2,765	743	1,855	1,105	6,468
1997	5,361	790	1,855	1,039	9,045
1998	5,681	1,029	1,855	973	9,538
1999	-	858	1,855	909	3,622
2000	-	1,049	1,855	843	3,747
2001	186	843	1,855	780	3,664
2002	174	1,056	1,855	714	3,799
2003	27	858	1,855	650	3,390
2004	-	843	1,855	584	3,282
2005	-2,843	843	1,855	518	373

* Residual repayment of Foreign Loan: 14,840

* Residual interest on Foreign Loan : 1,818

Table 9-6 Net Cash Flow

Unit: Million Rupiah

Period (Year)	Net Cash Flow
1984	-190
1985	-9,555
1986	-12,138
1987	-5,666
1988	-3,406
1989	4,991
1990	5,314
1991	6,008
1992	3,544
1993	4,208
1994	5,567
1995	6,498
1996	4,784
1997	3,004
1998	3,308
1999	10,448
2000	11,619
2001	12,946
2002	14,023
2003	15,679
2004	17,031
2005	20,221

*Residual repayment of Foreign Loan: 14,840

*Residual interest on Foreign Loan : 1,818

Table 9-7 Internal Financial Rate of Return

Unit: Million Rupiah

Period (Year)	Cost	Benefit	Present Value (14% discount)		Present Value (15% discount)	
			Cost	Benefit	Cost	Benefit
1984	684	494	684	494	684	494
1985	10,049	494	8,812	433	8,744	430
1986	19,397	7,258	14,916	5,581	14,664	5,488
1987	19,856	14,190	13,403	9,577	13,066	9,338
1988	21,069	17,664	12,472	10,457	12,051	10,103
1989	2,484	7,475	1,288	3,879	1,234	3,716
1990	2,195	7,509	1,000	3,425	948	3,244
1991	2,012	8,020	804	3,207	755	3,016
1992	4,987	8,531	1,750	2,994	1,630	2,790
1993	4,835	9,042	1,489	2,784	1,374	2,568
1994	4,019	9,585	1,085	2,589	992	2,366
1995	3,953	10,450	936	2,476	851	2,246
1996	6,468	11,252	1,344	2,339	1,210	2,105
1997	9,044	12,049	1,645	2,193	1,474	1,963
1998	9,538	12,846	1,525	2,056	1,344	1,811
1999	3,623	14,070	506	1,970	445	1,731
2000	3,747	15,366	462	1,890	401	1,645
2001	3,664	16,610	396	1,794	340	1,545
2002	3,774	17,822	359	1,694	306	1,445
2003	3,390	19,069	281	1,582	237	1,335
2004	3,283	21,313	240	1,484	200	1,239
2005	374	20,594	24	1,318	20	1,093
	Total		65,421	66,216	62,970	61,711
Benefit - Cost			+795		-1,259	

$$IFRR = 14 + \frac{795}{795 + 1,259} = 14.38\%$$

9-4. Economic Analysis

Basic values of costs and benefits to be used in economic analysis are based on the corresponding values used in financial analysis. That is to say, for financial data except trasfer expenditure, conversion of one kind or another is made according to their respective characteristics.

Coefficients used in such conversion are:

- Standard Conversion Factor: SCF
- Consumer Conversion Factor: CCF
- Shadow Wage Rate: SWR
- Average Consumer's Surplus per Subscriber: ACS

These coefficients are already calculated in Feasibility Study Report on Telecommunication Network in Developing Area, Surrounding Medan and Ujung Pandang, 1981, by Japan International Cooperation Agency. They are SCF: 0.985, CCF: 1.00, SWR: 0.59 and ACS: 1.05.

All these are up-to-date figures obtained, based on statistical data of Sulawesi area for 1977 and after. They can be used in the Feasibility Study, this time, also.

Basic values to be used in economic analysis have been obtained as shown below from the corresponding values used in financial analysis:

- Imported property (settlement by foreign currency budget) ... CIF price
- Non-trade property ... financial data x SCF (0.985)
- Skilled labor .... financial data x CCF (1.00)

- Unskilled labor ...... financial data x SWR (0.59)
  x CCF (1.00)
- Benefits .... financial data x SCF (0.985)
  x ACS (1.05)

Economic costs and benefits obtained by the method shown above are given in Table 9-8.

Internal Economic Rate of Return (IERR) of this Project calculated by economic costs and benefits obtained as per above becomes 12.10% as seen in Table 9-9. This IERR indicates that this Project, when economically analyzed, is feasible. It further shows that the implementation of this Project is desirable in a national economic sense.

Table 9-8 Economic Cost and Benefit

Unit: Million Rupiah

Period (Year)	Benefit	Cost		
		Investment	O/M Cost	Total
1984	-	665	-	665
1985	-	7,619	-	7,619
1986	-	16,028	-	16,028
1987	-	17,700	-	17,700
1988	3,591	17,703	535	18,238
1989	7,243	472	535	1,007
1990	7,766	-	716	716
1991	8,294	-	535	535
1992	8,824	2,430	716	3,146
1993	9,352	2,435	565	3,000
1994	9,912	-	748	748
1995	10,807	171	570	741
1996	11,638	2,567	565	3,132
1997	12,462	4,798	611	5,409
1998	13,286	5,097	836	5,933
1999	14,552	-	667	667
2000	15,891	-	856	856
2001	17,180	174	655	829
2002	18,434	171	863	1,034
2003	19,722	24	667	691
2004	21,010	-	655	655
2005	21,301	-2,843	655	-2,188

Table 9-9 Internal Economic Rate of Return

Unit: Million Rupiah

Period (Year)	Cost	Benefit	Present Value (12% discount)		Present Value (13% discount)	
			Cost	Benefit	Cost	Benefit
1984	665	-	665	-	665	-
1985	7,619	-	6,803	-	6,744	-
1986	16,028	-	12,775	-	12,550	-
1987	17,700	-	12,604	-	12,266	-
1988	18,238	3,591	11,599	2,283	11,181	2,200
1989	1,007	7,243	570	4,107	545	3,926
1990	716	7,766	362	3,931	342	3,728
1991	535	8,294	242	3,750	227	3,525
1992	3,146	8,824	1,271	3,564	1,183	3,317
1993	3,000	9,352	1,083	3,376	1,000	3,114
1994	748	9,912	242	3,192	220	2,924
1995	741	10,807	213	3,102	193	2,821
1996	3,132	11,638	804	2,992	724	2,689
1997	5,409	12,462	1,239	2,853	1,102	2,542
1998	5,933	13,286	1,217	2,723	1,073	2,405
1999	667	14,552	122	2,662	108	2,327
2000	856	15,891	139	2,591	120	2,242
2001	829	17,180	120	2,508	103	2,149
2002	1,034	18,434	134	2,396	115	2,046
2003	691	19,722	81	2,288	68	1,934
2004	655	21,010	68	2,185	56	1,828
2005	-2,188	21,301	-203	1,980	-169	1,640
	Total		52,150	52,483	50,416	47,357
Benefit - Cost			+333		-3,059	

$$IERR = 12 + \frac{333}{333 + 3,059} = 12.10\%$$

9-5. Sensitivity Analysis

The foregoing financial and economic analyses on the assumption that this Project will be completed as schedules, based on all conditions and requirements so far described, and the system constructed will be commissioned as planned arrive at this conclusion: Both financially and economically, this Project is feasible.

Now, assume that this Project will be completed, not as envisaged by the aforementioned conditions and requirements but in the pessimistic direction in terms of project finance. Sensitivity analysis in that event follows:

(1) In case where the amount of capital investment increases by 10%, i.e., where a full amount of contingency is spent in addition to capital investment:

IFRR = 11.64%

IERR = 10.84%

This Project, when financially analyzed, cannot be feasible.

Nevertheless, when economically considered, this Project can still be feasible to a certain extent.

(2) In case where demand forecast is optimistic, causing actual traffic to be smaller than the forecasted size, hence operating revenue to descrease by 10%:

IFRR = 12.34%

IERR = 10.64%

In this case, financially, this Project can be feasible to a certain degree. Economically also, it can be feasible to a certain extent.

(3) In case where the initial stage work period has been protracted due to circumstances, causing the completion of work to delay two years behind schedule:

IFRR = 9.79%

IERR = 10.82%

In this case, this Project cannot be feasible financially, but economically, is still feasible to some extent.

(4) In case where the foregoing three conditions are combined:

IFRR = 8.98%

IERR = 8.41%

In this case, this Project cannot be feasible both financially and economically.

The important point that derives from the above sensitivity analysis is that the delay of service-in due to protraction of work execution will affect this Project fatally. Therefore, in the implementation of this Project, special consideration is required to have all works done as planned, i.e., without delay behind schedule.

9-6. Evaluation

Sulawesi area assumes no less importance than Jawa and Sumatera areas in social and economic development of Indonesia. Today, in Sulawesi area, the regional economic level is drawing close, though gradually, to the national average. There is much to expect from the vast potential power of the area which, if properly developed, will make important contributions to the further growth of Indonesian economy in the future.

However, telecommunication service, especially telephone service, as an indispensable means of economic and other organized activities in modern society is available only in big cities including provincial capitals and several other cities. Service improvement and expansion are storongly desired. Should service remain underdeveloped as it now is, future social and economic development of the area may be seriously impeded.

Backbone transmission route that interconnect big cities are developed to some extent as the domestic telecommunication satellite system and HF communication system are available. In spite of these systems, services still remain deficient not only quantitatively but qualitatively as well.

Solution to such service deficiency is urgently required. And this solution must of course be sought within financial and economic feasibility limites.

Today, the development level of telecommunication technology is such that up-to-date, sophisticated telephone service can be realized, wherever the place, if the cost is not considered. Actually, there are limits to telephone service improvement. First, the economic restraint cannot be ignored. Second, the effective utilization of existing facilities must be taken into account with a view to formation of telecommunication system as it should be.

The Project studied, this time, is considered to be optimum, technically and economically, out of many project plans formulated in the presence of restrictions and difficulties as aforementioned.

Conclusion arrived at in the Study of this Project is that the proposed terrestrial transmission network for Sulawesi area should be realized as early as possible as a means of telecommunication service improvement in the area.

In this connection, the greatest problem to be considered is whether the required fund can be procured in full by the present-day Indonesia alone. Considering the degree of economic effect of Sulawesi Area Terrestrial Transmission Network Project, as well as its political and social impacts, the best way to solution is, to be sure, to seek foreign financial assistance in the form of soft loan.

There is little reason to doubt that the proposed Sulawesi Area Terrestrial Transmission Network Project can be most effectively realized by long term, low interest financial aid from foreign source, and that the Project so realized will contribute best to further economic and social development of Indonesia.