The rapid economic expansion according to its past trend may induce unfavorable effects to the macro-economic settings.

i) Deterioration of the external balance or current account conditions as a result of trade balance deficit and stagnant in net capital inflow.

ii) The domestic stabilization or inflationary pressure and its adverse effect on income distribution.

iii) The shortage of engineers, and professional personnels in the manufacturing sector, water supply shortages in the agriculture sector.

The 7th Plan thus sets targets for its achievable levels. That is to say, there are three possible policy actions to lessen the the adversary effects if nothing is being done or if the economy is not monitored.

i) The private sector consumption may be considered to be lessened so that households savings would be increased.

ii) The export drive of the private sector may be monitored to be in accordance with the world demand.

iii) The selective scheme introduced to screen investment projects so that only effective projects are selected.

In practice, the planned targets of ii) and iii) are not feasible as far as the export of Thailand is more or less exogenous to the policy control while the investment criteria are not effectively implemented as Thailand is badly in need of the infrastructure and huge investment from the private sector. Thus, only the first alternative is the only option left. In the 7th Plan, it is assumed that the savings target is set as follows.

	1989	1996	
		Trend	Target
Private Savings	19.2	18.9	23.1
- Households	10.2	10.3	14.5
- Business	9.0	8.6	8.6

The forced saving gives rise to the declining of the private consumption of 7.7 percent per year to 5.7 percent per year. The economic expansion has been slowed down to the level of 8.2 percent per year as compared with 8.8 percent in the base or past trend case.

	Forecasted Case		
	Base	Target	Diff.
1. Economic Performances (%)	8.8	8.2	-0.6
- Agriculture	3.4	3.4	-0.0
- Manufacture	9.9	9.5	-0.4
- Construction	8.9	8.0	-0.9
2. Inflation (%)	6.6	5.6	-1.0
3. Private Investment	9.6	8.8	-0.8
4. Balance of Trade (Average per year 10 00 million baht)	371.2	313.0	-58.2
5. Current Account (in '000 million baht)	232.0	170.3	-61.7
Current AC / GDP (%)	-6.6	-5.2	+1.4

Table 2.2.3-1 Key Economic Indicator for the Seventh Plan

	Average 4th Plan (1977-1981)	Average 5th Plan (1982-1986)	Average 6th Plan (1987-1991)	Average 7th Plan Base Case	Target
1. Real Economic Growth (%)					
1.1 Agriculture	4.0	3.9	3.5	3.4	3.4
1.2 Non-Agriculture	8.4	5.7	12.1	9.2	8.6
- Manufacturing	8.1	5.6	13.7	9.9	9.5
- Construction	9.1	2.7	18.7	9.4	8.9
- Others	8.2	7.6	11.0	8.9	8.0
1.3 Gross Domestic Product	7.4	5.4	10.5	8.8	8.2
2. Expenditure (Growth, %)					
2.1 Private					
- Consumption	5.8	4.6	9.1	7.7	5.7
-Investment	8.0	2.9	26.2	9.6	8.8
2.2 Government					
-Consumption	11.0	5.1	1.8	3.4	3.3
-Investment	13.1	2.2	6.5	8.6	8.5
3. Merchandise Exports					
3.1 Value (Bil.Baht)	108.4	179.8	496.2	1,044.4	1,062.7
3.2 Value Growth (%)	20.1	9.6	24.6	14.0	14.7
4. Tourism Revenue					
4.1 Billion Baht	11.9	29.1	91.4	182.7	185.0
4.2 Growth rate (%)	42.7	12.2	27.4	13.2	13.3
5. Merchandise Imports					
5.1 Value (Bil.Baht)	153.4	233.8	664.3	1,415.5	1,375.7
5.2 Value Growth (%)	25.1	3.1	32.6	12.5	11.4
6. Trade Balance					
6.1 Value (Bil.Baht)	(45.0)	(64.0)	(168.1)	(371.2)	(313.0)
6.2 Trade Balance/GDP (%)	(7.6)	(5.7)	(8.4)	(10.5)	(9.4)
7. Current Account					
7.1 Value (Bil.Baht)	(37.4)	(34.9)	(98.8)	(231.1)	(170.3)
7.2 Current Account/GDP (%)	(6.4)	(3.7)	(4.9)	(6.6)	(5.2)
8. Inflation (CPI)	11.6	2.8	4.7	6.7	5.6
9. Population (Million)*	48.5	52.5	56.9	61.0	61.0
10. Per Capita Income (Baht)* (GDP/Capita)	15,673.0	20,865.0	41,021.0	77,208.6	71,706.0

Note : All Baht figures are in current prices
* : Figures of the last year of the plan

Table 2.2.3-2 Key Economic Indicator for the Sixth Plan

	Average 5th Plan (1982-1986)	1987	1988	1989	1990	1991	Average 6th Plan (1987-1991)
1. Real Economic Growth (%)							
1.1 Agriculture	3.9	-0.2	10.2	6.6	-1.8	2.5	3.5
1.2 Non-Agriculture	5.7	11.8	13.5	13.1	12.3	9.8	12.1
-Manufacturing	5.6	13.3	16.8	14.9	13.7	10.0	13.7
-Construction	2.7	13.3	21.3	21.3	22.7	15.0	18.7
-Others	7.6	11.0	12.1	11.8	10.8	9.1	11.0
1.3 Gross Domestic Product	5.4	9.5	13.2	12.0	10.0	8.0	10.5
2. Real Expenditure							
2.1 Private							
-Consumption	4.6	8.8	8.8	10.9	9.1	8.0	9.1
-Investment	2.9	29.5	50.7	15.7	23.0	12.0	26.2
2.2 Government							
-Consumption	5.1	0.9	3.5	-0.1	2.9	2.0	1.8
-Investment	2.2	-13.1	-11.2	5.7	33.3	18.0	6.5
3. Merchandise Exports							
3.1 Value (Bil.Baht)	179.8	298.1	399.2	509.9	584.0	690.0	196.2
3.2 Value Growth (%)	9.6	28.8	33.9	27.7	14.5	18.2	24.6
4. Tourism Revenue							
4.1 Billion Baht	29.1	50.0	78.9	96.4	111.7	120.0	91.4
4.2 Growth rate (%)	12.2	34.0	57.6	22.2	15.9	7.4	27.4
5. Merchandise Imports							
5.1 Value (Bil.Baht)	233.8	341.4	501.4	650.7	838.0	990.0	664.3
5.2 Value Growth (%)	3.1	39.3	46.9	29.8	28.8	18.1	32.6
6. Trade Balance							
6.1 Value (Bil.Baht)	(54.0)	(43.3)	(102.2)	(140.8)	(254.0)	(300.0)	(168.1)
6.2 Trade Balance/GDP (%)	(5.7)	(3.5)	(6.8)	(7.9)	(11.7)	(11.9)	(8.4)
7. Current Account							
7.1 Value (Bil.Baht)	(34.9)	(9.3)	(41.8)	(63.7)	(179.0)	(200.0)	(98.8)
7.2 Current Account/GDP (%)	(3.7)	(0.7)	(2.8)	(3.6)	(8.7)	(8.5)	(4.9)
8. Inflation (CPI)	2.8	2.5	3.8	5.4	6.0	6.0	4.7
9. Population*(Million Persons)	52.5	53.4	54.3	55.2	56.1	56.9	56.9
10. Per Capita Income* (Baht) (GDP/Capita)	20,860	23,454	27,737	32,094	36,399	41,021	41,021

Note : All Baht figures are in current prices
* : Figures of the last year of the plan

Table 2.2.3-3 Key Economic Indicator for the Seventh Plan (Base Case)

	Average 6th Plan (1987-1991)	1992	1993	1994	1995	1996	Average 7th Plan (1992-1996)
1. Real Economic Growth (%)							
1.1 Agriculture	3.5	3.7	3.4	3.5	3.4	3.3	3.4
1.2 Non-Agriculture	12.1	9.8	9.2	9.1	9.1	9.0	9.2
-Manufacturing	13.7	10.8	9.7	9.7	9.6	9.6	9.9
-Construction	18.7	9.0	9.7	9.6	9.5	9.4	9.4
-Others	11.0	9.3	8.8	8.8	8.7	8.7	8.9
1.3 Gross Domestic Product	10.5	9.3	8.7	8.7	8.6	8.6	8.8
2. Real Expenditure							
2.1 Private							
-Consumption	9.1	8.7	7.5	7.5	7.4	7.3	7.7
-Investment	26.2	8.8	9.9	9.9	9.8	9.8	9.6
2.2 Government							
-Consumption	1.8	3.7	3.3	3.3	3.3	3.3	3.4
-Investment	6.5	8.6	8.7	8.6	8.5	8.4	8.6
3. Merchandise Exports							
3.1 Value (Bil.Baht)	496.2	800.3	906.6	1,027.8	1,165.3	1,321.8	1,044.4
3.2 Value Growth (%)	24.6	16.3	13.3	13.4	13.4	13.4	14.0
4. Tourism Revenue							
4.1 Billion Baht	91.4	140.5	159.1	180.1	203.7	230.2	182.7
4.2 Growth rate (%)	27.4	13.3	13.2	13.2	13.1	13.0	13.2
5. Merchandise Imports							
5.1 Value (Bil.Baht)	664.3	1,120.2	1,252.4	1,399.3	1,562.4	1,743.3	1,415.5
5.2 Value Growth (%)	32.6	16.0	11.8	11.7	11.7	11.6	12.5
6. Trade Balance							
6.1 Value (Bil.Baht)	(168.1)	(319.9)	(345.8)	(371.5)	(397.2)	(421.4)	(371.2)
6.2 Trade Balance/GDP (%)	(8.4)	(12.0)	(11.3)	(10.5)	(9.7)	(8.9)	(10.5)
7. Current Account							
7.1 Value (Bil.Baht)	(98.8)	(211.6)	(224.0)	(234.4)	(242.7)	(247.6)	(232.1)
7.2 Current Account/GDP (%)	(4.9)	(7.9)	(7.3)	(6.6)	(5.9)	(5.3)	(6.6)
8. Inflation (CPI)	4.7	6.3	6.4	6.6	6.9	7.1	6.7
9. Population*(Million Persons)	56.9	57.8	58.6	59.4	60.2	61.0	61.0
10. Per Capita Income* (Baht) (GDP/Capita)	41,021	46,300	52,474	59,583	67,770	77,209	77,209

Note : All Baht figures are in current prices
* : Figures of the last year of the plan

Table 2.2.3-4 Key Economic Indicator for the Seventh Plan (Target)

	Average 6th Plan (1987-1991)	1992	1993	1994	1995	1996	Average 7th Plan (1992-1996)
1. Real Economic Growth (%)							
1.1 Agriculture	3.5	3.4	3.4	3.5	3.3	3.3	3.4
1.2 Non-Agriculture	12.1	9.1	8.7	8.7	8.3	8.3	8.6
-Manufacturing	13.7	10.1	9.6	9.5	9.2	9.2	9.5
-Construction	18.7	9.2	9.6	9.5	8.3	8.2	8.9
-Others	11.0	8.6	8.2	8.1	7.8	7.8	8.1
1.3 Gross Domestic Product	10.5	8.6	8.3	8.3	7.9	7.9	8.2
2. Real Expenditure							
2.1 Private							
-Consumption	9.1	7.1	5.7	5.5	5.1	4.9	5.7
-Investment	26.2	8.9	9.4	9.4	8.2	8.2	8.8
2.2 Government							
-Consumption	1.8	3.3	3.3	3.3	3.3	3.3	3.3
-Investment	6.5	8.7	9.2	9.1	7.7	7.7	8.5
3. Merchandise Exports							
3.1 Value (Bil.Baht)	496.2	799.4	912.8	1,042.9	1,193.1	1,365.4	1,062.7
3.2 Value Growth (%)	24.6	16.3	14.2	14.3	14.4	14.4	14.7
4. Tourism Revenue							
4.1 Billion Baht	91.4	141.3	160.5	182.1	206.6	234.4	185.0
4.2 Growth rate (%)	27.4	12.4	13.6	13.5	13.4	13.4	13.3
5. Merchandise Imports							
5.1 Value (Bil.Baht)	664.3	1,111.8	1,234.5	1,368.6	1,506.7	1,656.8	1,375.7
5.2 Value Growth (%)	32.6	15.0	11.0	10.9	10.1	10.0	11.4
6. Trade Balance							
6.1 Value (Bil.Baht)	(168.1)	(312.4)	(321.7)	(325.7)	(313.6)	(291.5)	(313.0)
6.2 Trade Balance/GDP (%)	(8.4)	(11.8)	(10.7)	(9.5)	(8.1)	(6.7)	(9.4)
7. Current Account							
7.1 Value (Bil.Baht)	(98.8)	(202.6)	(197.5)	(185.3)	(154.6)	(111.4)	(170.3)
7.2 Current Account/GDP (%)	(4.9)	(7.6)	(6.6)	(5.4)	(4.0)	(2.5)	(5.2)
8. Inflation (CPI)	4.7	5.7	5.4	5.6	5.6	5.7	5.6
9. Population*(Million Persons	) 56.9	57.8	58.6	59.4	60.2	61.2	61.0
10. Per Capita Income* (Baht) (GDP/Capita)	41,021	45,849	51,303	57,475	64,176	71,706	71,706

Note : All Baht figures are in current prices
* : Figures of the last year of the plan

Table 2.2.3-5 Fiscal Balance (Fiscal Year)

	Revenue	Expenditure	Balance	Change(%) Revenue	Change(%) Expenditure
1977	51.7	62.9	-11.2	21.5	17.2
1778	62.0	74.7	-12.7	19.9	18.8
1979	75.0	86.0	-11.0	21.0	15.1
1980	92.5	114.3	-21.8	23.3	32.9
1981	110.3	129.9	-19.6	19.2	13.6
Avg.4 th Plan	78.3	93.6	-15.3	21.0	19.5
1982	113.8	152.2	-38.4	3.2	17.2
1983	136.4	165.1	-26.7	19.9	8.5
1984	147.8	177.4	-29.6	8.4	7.5
1985	159.2	197.5	-38.3	7.7	11.3
1986	165.3	204.0	-38.7	3.8	3.3
Avg.5 th Plan	144.5	179.2	-34.7	8.6	9.5
1987	192.5	207.8	-15.3	16.5	1.9
1988	245.6	220.6	-25.0	27.6	6.2
1989	309.2	248.3	60.9	25.9	12.6
1990	395.0	291.2	103.8	27.7	17.3
1991	440.0	345.0	95.0	11.4	18.5
Avg.6 th Plan	316.5	262.6	53.9	21.8	11.3
1992	497.0	410.0	87.0	13.0	18.8
1993	571.5	461.0	110.5	15.0	12.4
1994	657.0	519.0	138.0	15.0	12.6
1995	756.0	583.0	173.0	15.1	12.3
1996	869.0	657.0	212.0	14.9	12.7
Avg.7 th Plan	670.1	526.0	144.1	14.6	13.8

2.3 Regional Development Framework

The national economic plan and the development of the Bangkok Metropolitan Region are quite closely interrelated. This is owing to the fact that Bangkok has the greatest shares in various aspects of production, consumption, investment and import and export. This is not to mention the role played in the policy making process, the taxation and public expenditure and investment.

The economic expansion during the 6th Plan period(1987-1991), which experienced the 10.8 % average annual growth rate has induced structural changes of industries and urbanization. At present, the urban population size is 18.3 millions or 32 percent of the total population. Among these, 42 percent or equivalently 7.7 million people reside in the Bangkok Metropolitan Region (BMR).

It is predicted that the urban population will go up to 33 millions or 46 percent of the total population in the next 20 years. The BMR population will go up to 12 millions and almost 2 million people have to live in the slum area. This immediately calls for more and better infrastructure, environmental protection, housing and measures to protect or remedy the inequality of income which will be seriously deteriorated in the BMR.

In the 7th Plan, it is necessary to consider how to finance local public services, restructuring of the legal system and local tax and public finance to cope with the changing needs of infrastructures. The most important is how to decentralize local systems so that it can independently function without causing conflicts between the central government and local governments.

2.3.1 Definition

According to the current administrative definition, the Bangkok Metropolitan Region (BMR) consists of 36 districts of the Bangkok Metropolitan Area (BMA) [1] and the five surrounding provinces, Pathum Thani, Nonthaburi, Samut Prakan, Samut Sakhon, and Nakon Pathum. This study, however, includes Ayutthaya province as a part of the Study Area and takes the area as the redefined extended BMR, larger than the current administrative definition. Ayutthaya will be integrated into the BMR in the foreseeable future since the most rapid current urban and economic expansion of the BMR has been taking place along Route 1, going to the north of the BMR and now reaching to the southern edge of Ayutthaya province.

In the telecommunications sector, the BMA and the surrounding provinces have been traditionally grouped as Telecom Bangkok Metropolitan Administrative Area (Telcom BMA),

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[1] Note: The 36 districts of the BMA are classified into the following three administrative groups:

1) Inner Zone
   Phranakorn, Pomprab, Pathumwan, Sampantawong, Bangkrak, Bangkokyai, Dusit, Bang Sue, Phyathai, Ratcha Thewi, Huai Kwang, Thonburi, Klongsan
2) Middle Zone
   Yannawa, Bang Kholaem, Sathon, Prakanong, Prawet, Khlong Toey, Bangkhen, Don Muang. Cha Tu Chak. Bangkapi, Bang Kum, Lat Phrao, Bangkoknoi, Bang Phlat, Pasicharoen, Ratburana
3) Outer Zone
   Bangkhunthian, Jom Thong, Talingchan, Nongkhaem, Minburi, Latkrabung, Nongchok

which consists of the BMA, Pathum Thani, Nonthaburi, Samut Prakan. The figure 2.3.1-1 and 2 show the administrative boundaries and the telecom exchange areas.

In this report, the BMA means the Telecom BMA and, the administrative BMA is termed as the ABMA in this report. Hence, the extended BMR defined in this section corresponds to the Study Area. The BMR in this chapter includes Ayutthaya province.

2.3.2 The Structure of the BMR

It has passed more than 200 years since a little fishing village by the Chao Phraya River became the capital of the Kingdom of Thailand, namely Bangkok, to which Thai people still affectionately call Krung Thep (City of Angels). Bangkok grew as the center of political, economical, cultural, and social activities as Thailand grew. It has become the 20th largest city in the world and holds 9.3 million people as its population. Since Bangkok developed on the delta of the Chao Phraya River, people constructed a network of canals for transportation and flood control. The city primarily developed along the canals. Because of the canals, Bangkok is often called Venice of the Orient. The beauty of the palace, temples, and the view along the Chao Praya River, and the hospitality and smile of Thai people fascinated tourists from all over the world. Bangkok became one of major tourist spots in the Southeast Asia.

The population of the BMR was 5 million in 1970, 7.8 million in 1980, and grew up to 9.2 million in 1990. The average annual population growth rate of the BMR was 6 % in the 70's and 2 % in the 80's while the national average of annual population growth rate was 3 % in the 70's and 2 % in the 80's. At the early period of the 60's, the city boundary was limited within the Bangkok and Tonburi districts. As the population grew rapidly, the city boundary also expanded and urbanization progressed rapidly. Table 2.3.2-1, 2 and 3 show the population statistics, GDP statistics and employment statistic, respectively.

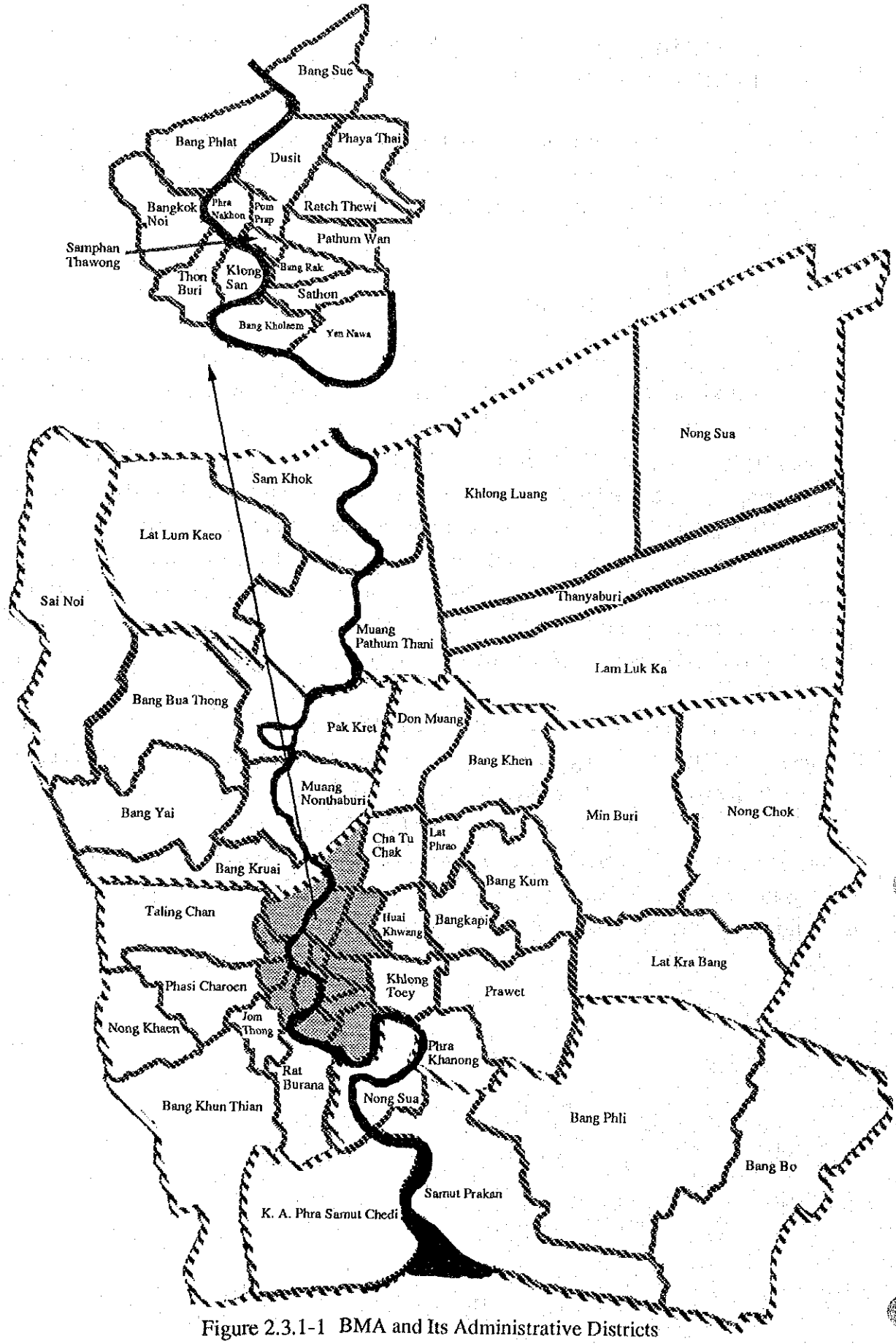


Figure 2.3.1-1 BMA and Its Administrative Districts

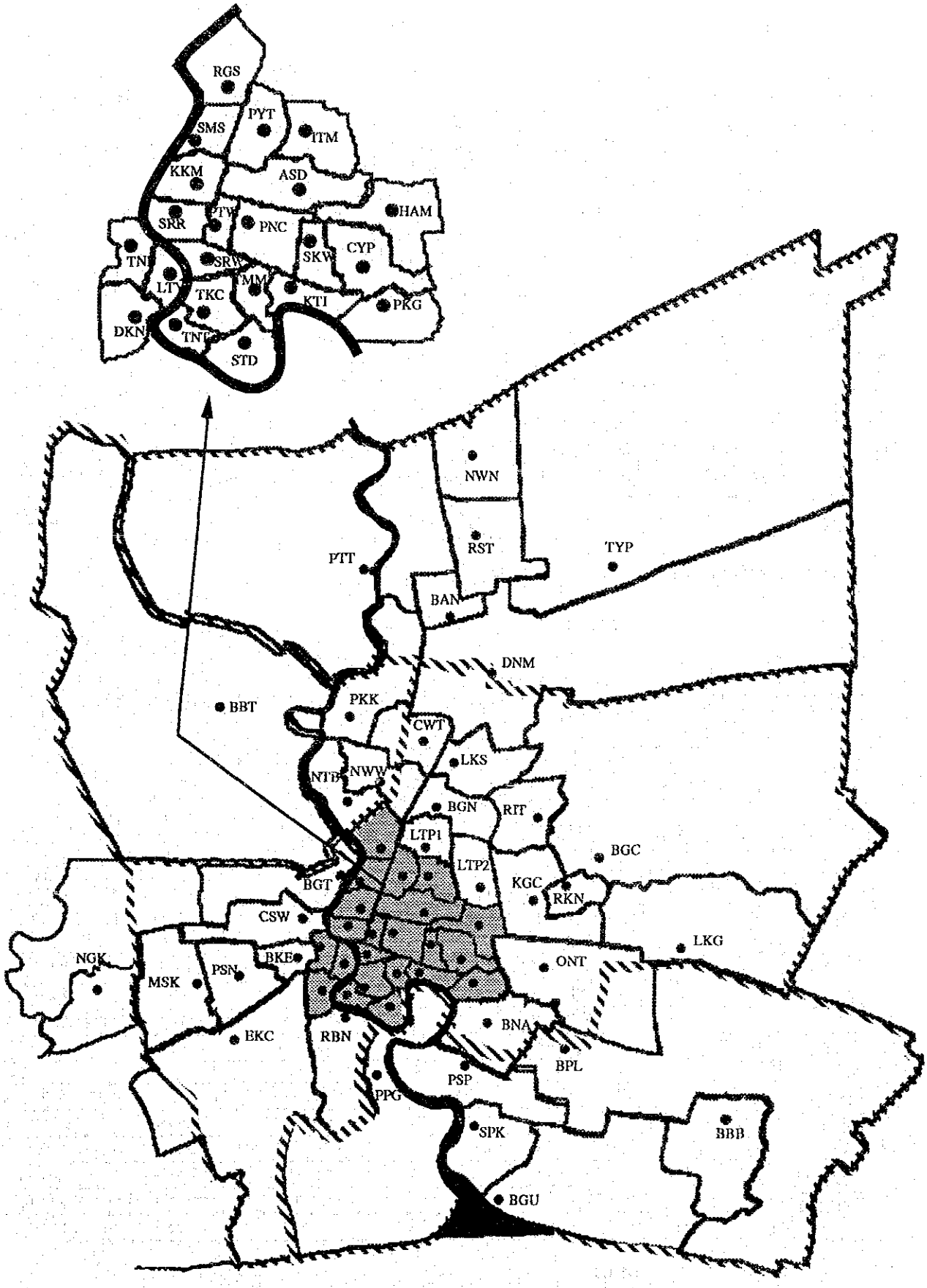


Figure 2.3.1-2 Local Exchange Areas in the BMA

Table 2.3.2-1 The Population Statistics in the BMR

Area	*1970*	*1980*	*1985*	*1986*	*1987*	*1988*	*1989*	*1990*
Bangkok Metro.	3,077,361	5,153,902	5,363,378	5,468,915	5,609,352	5,716,779	5,832,843	5,546,937
Nontha-buri	269,067	386,741	504,424	525,475	571,871	596,381	627,667	668,760
Samut Prakan	329,404	535,858	662,612	689,631	741,905	789,060	829,412	854,883
Pathum Thani	233,861	324,468	384,713	402,080	415,193	435,409	441,930	452,693
Nakhon Pathom	419,319	561,346	609,316	617,596	619,518	630,805	646,803	657,182
Samut Sakhon	200,460	242,994	315,373	327,677	334,170	340,952	349,680	358,155
Ayutthaya	501,737	623,242	652,977	664,245	668,611	677,626	680,100	685,394
BMA	3,909,693	6,400,969	6,915,127	7,086,101	7,338,321	7,537,629	7,731,852	7,523,273
BMR	5,031,209	7,828,551	8,492,793	8,695,619	8,960,620	9,187,012	9,408,435	9,224,004
Whole Kingdom	35,550,105	46,861,338	51,795,651	52,969,204	53,873,172	54,960,917	55,537,648	N.A.

Source: Local Administration Department/Ministry of Interior

Table 2.3.2-2 The GPP Statistics in the BMR
(at 1972 prices; Thousand Baht)

Area	1981-84	1985	1986	1987	1988	1989
Bangkok Metro.		129,193,901.6	134,509,642.7	154,876,858.4	178,805,100.1	202,218,703.9
Growth Rate p.a.	5.88%	2.36%	4.11%	15.14%	15.45%	13.09%
Nonthaburi		5,454,926.0	5,840,120.0	6,616,231.0	8,784,029.0	10,658,856.5
Growth Rate p.a.	6.65%	2.16%	7.06%	13.29%	32.76%	21.34%
Samut Prakan		14,933,718.0	16,211,173.0	19,583,143.0	24,646,479.0	28,728,347.9
Growth Rate p.a.	5.17%	-0.09%	8.55%	20.80%	25.86%	16.56%
Pathum Thani		8,712,342.0	10,034,260.0	10,563,568.0	11,286,264.0	13,395,550.9
Growth Rate p.a.	15.90%	-0.43%	15.17%	5.28%	6.84%	18.69%
Nakhon Pathom		5,430,330.0	5,612,129.0	5,913,428.0	6,337,600.0	6,974,343.0
Growth Rate p.a.	4.80%	17.98%	3.35%	5.37%	7.17%	10.05%
Samut Sakhon		4,612,696.0	5,820,041.0	6,726,497.0	7,068,030.0	7,720,906.1
Growth Rate p.a.	4.68%	43.42%	26.17%	15.57%	5.08%	9.24%
Ayutthaya		4,261,202.0	4,318,878.0	4,302,342.0	4,632,024.0	5,221,757.1
Growth Rate p.a.	1.17%	18.79%	1.35%	-0.38%	7.66%	12.73%
BMA		158,294,887.6	166,595,195.7	191,639,800.4	223,521,872.1	255,001,459.3
Growth Rate p.a.	6.29%	1.96%	5.24%	15.03%	16.64%	14.08%
BMR		172,599,115.6	182,346,243.7	208,582,067.4	241,559,526.1	274,918,465.5
Growth Rate p.a.	6.21%	3.56%	5.65%	14.39%	15.81%	13.81%
Whole Kingdom		394,113,015.6	413,490,151.7	452,636,241.4	512,466,435.1	574,194,915.0
Growth Rate p.a.	6.09%	3.51%	4.92%	9.47%	13.22%	12.05%

Source: National Accounts Division/NESDB

Table 2.3.2-3 The Employment statistics in the BMR

Area	*1984*	*1985*	*1986*	*1987*	*1988*	*1989*
Bangkok Metro.	774,746	N.A.	850,273	1,122,771	1,316,425	1,553,021
Nonthaburi	45,153	N.A.	45,693	49,145	60,669	65,568
Samut Prakan	137,515	N.A.	138,337	155,407	195,836	255,954
Pathum Thani	49,865	N.A.	52,634	58,210	76,570	95,431
Nakhon Pathom	36,816	N.A.	37,416	38,318	47,268	60,092
Samut Sakhon	37,067	N.A.	36,267	38,595	54,299	68,356
Ayutthaya	18,829	N.A.	17,992	19,139	27,561	30,786
BMA Total	1,007,279	N.A.	1,086,937	1,385,533	1,649,500	1,969,974
BMR	1,099,991	N.A.	1,178,612	1,481,585	1,778,628	2,129,208
Whole Kingdom	1,710,120	N.A.	1,772,767	2,144,853	2,494,702	2,962,025

Source : Department of Labour/Ministry of Interior

1) Rapid urbanization brought the following problems to the BMR:

a) Unskilled young workers who could not find jobs in their native cities and areas and farmers who had to find ways to feed their families during non-farming seasons and poor harvest periods have been pouring into the relatively employment opportunity rich BMR since provincial cities in Thailand are too small in their economic activities to provide a job to every person in the labor pool. Hence, the BMR has been in short of housing supply and experiencing rapid increase of land and rental prices. Middle-income class people have been moving toward the suburbs while the already high density old city area has been left for urban poors and converted into slum areas.

b) Permanent traffic congestion.

c) Shortage of basic infrastructure facilities and services and decreasing quality of public services in water supply, sewage, garbage and industrial waste disposal, electricity, telecommunications, fire service, education, health care.

d) Increase of criminal activities.

e) Air pollution.

f) Ground subsidence and flood problems.

g) Disorderly destruction of forests into disorganized development of urban land use.

The current business and residential areas of the A BMA are mostly concentrated at the eastern side of the Chao Phraya River. It has become eminent that shortage and poor conditions of roads and industrial water supply created bottle-neck conditions for further development in the eastern side of the Chao Phraya River area. The same situations in housing, electricity, and telecommunications infrastructure follow as the next bottle-neck

problems. The canals, one of once major tourist attraction resources, and weak and low level land foundation have become negative factors for further development.

As the number of people living in the suburbs increases, the number of commuters into the city also increases. People, however, have to rely on their cars, buses, samuros, motorcycles to commute since mass transit systems such as trains or subways are underdeveloped. Trucks and vans are also used for transporting materials and products. Some canals were converted into main roads and highways were built in the BMR; however, the BMR lacks branch and service roads which are essential to organize an effective road network by connecting main roads. Hence, traffic congestion is permanent and serious.

Land subsidence caused by unexpected and unplanned over-use of underground water for rapidly expanding industries is another serious problem in the BMR. Industrial location is now severely restricted in the BMR since flood control became more difficult because of land subsidence.

Major socio-economic activities in the BMR have been predominantly taking place along with main roads which are relatively well equipped with basic infrastructure. Since the shortage problem of basic infrastructure will not be solved in the near future, the development will be remained along with main roads connecting outer commercial, residential centers and industrial estates.

2.3.3 Regional Development Framework from 1992 to 2007

1) Strategic Target Areas in the 6th National Development Plan

The 6th National Development Plan formulated spatial development strategies for the BMR. According to the plan the BMR is divided into four strategic target areas to promote over-all spatial development. The development is conceptualized around the buildings of three ring roads, Rachada Ring Road, Middle-ring Road, and Outer-ring Road, which surround the major part of the ABMA from the inner to the outer areas. The Outer-ring Road surrounds the 25 Km (the east-west direction) by 50 Km (the north-south direction) area of the ABMA. The three ring roads will play vital roles in connecting roads and highways running the east-west and north-south directions and creating an effective metropolitan road/highway network system. Figure 2.3.3-1 and 2 show the future development direction in the BMR, and the land use plan in general town plan of the BMA and major urban areas in the year of 2000.

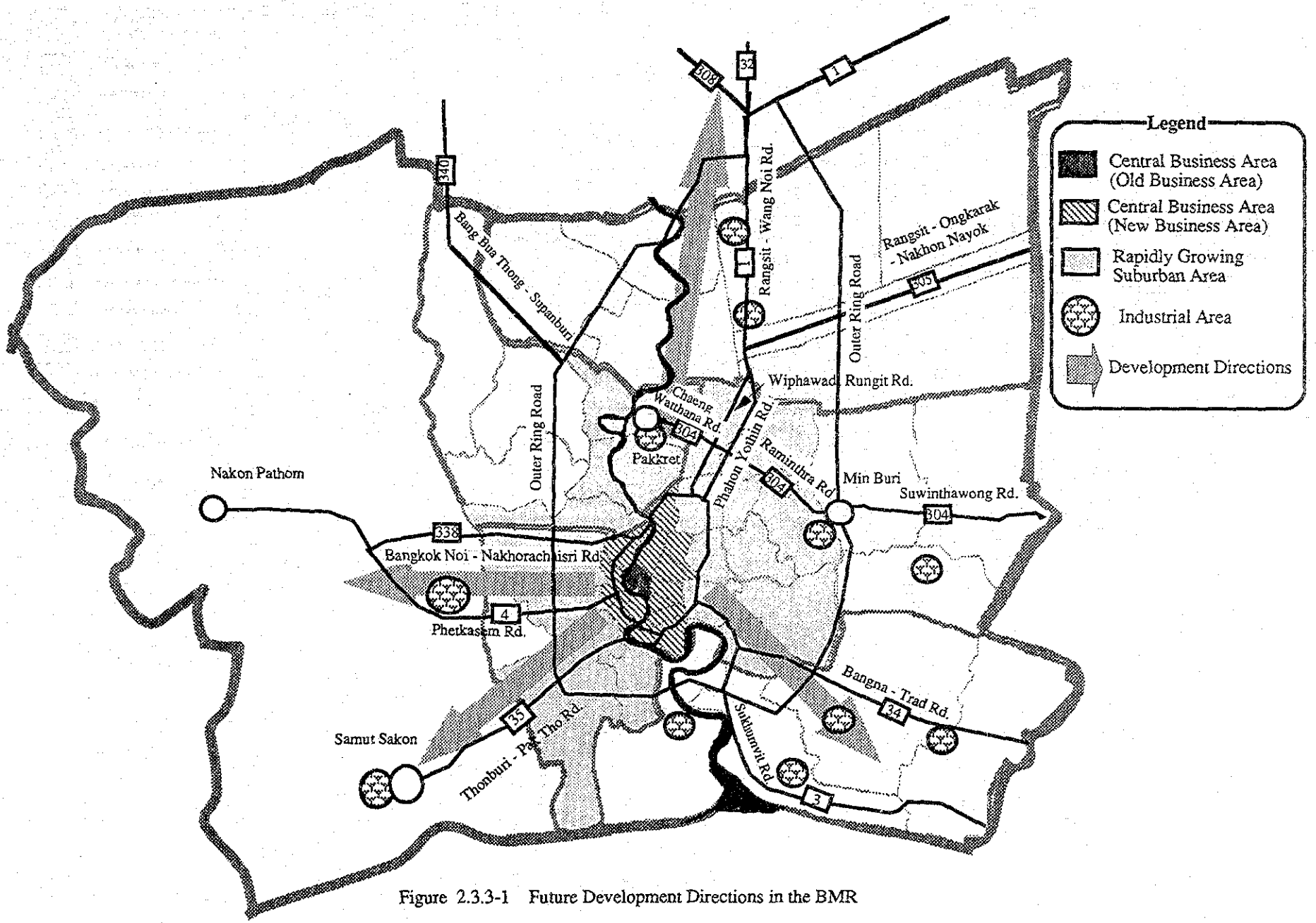


Figure 2.3.3-1 Future Development Directions in the BMR

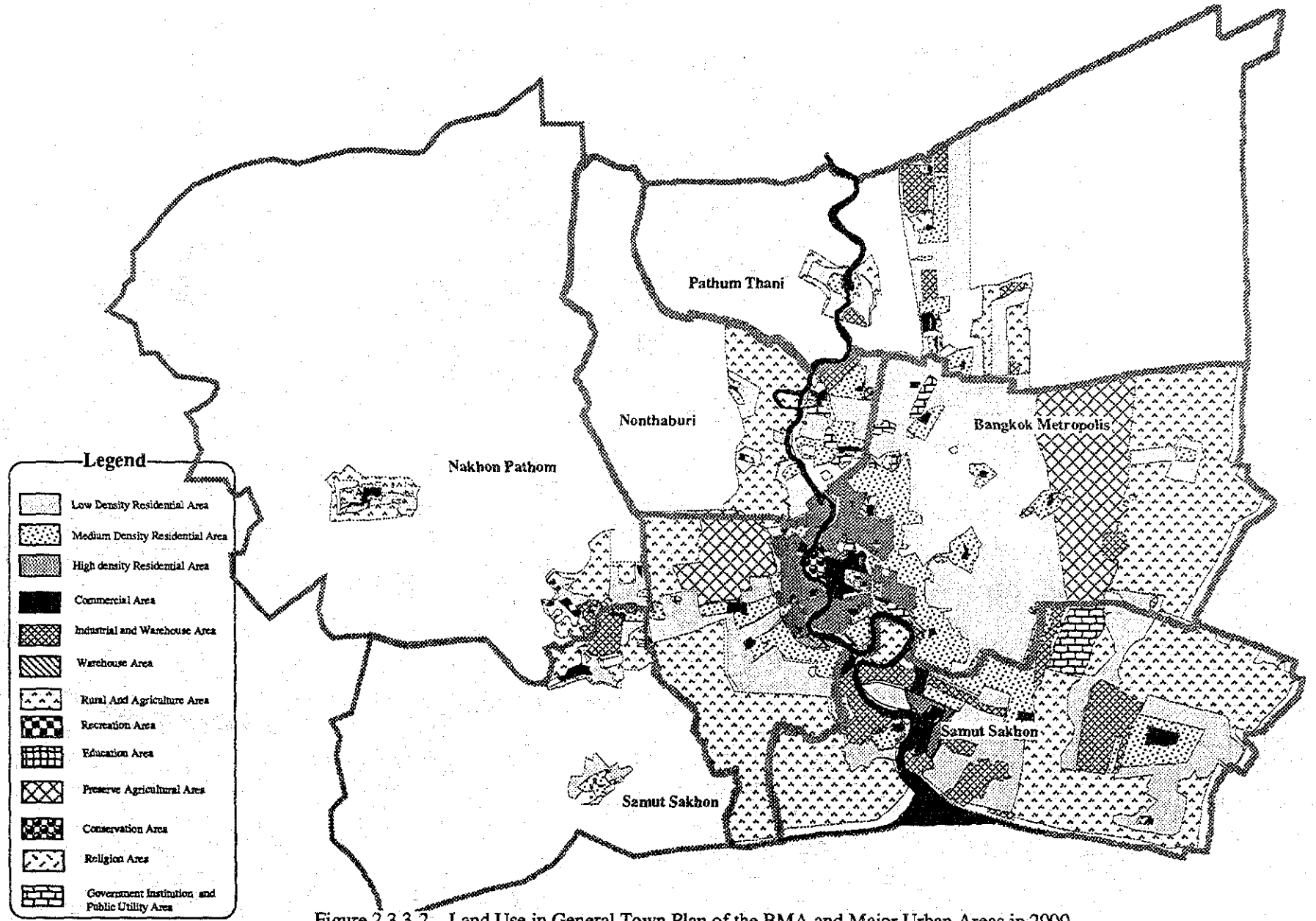


Figure 2.3.3-2 Land Use in General Town Plan of the BMA and Major Urban Areas in 2000

a) Central Business Area (Area: 147 Km^2, Population: 3.3 Million in 1990)

i) The area mainly consists of 12 districts of the ABMA surrounded by the Rachada Ring Road.

ii) Old Business Area (Area: 9 Km^2):

Phranakorn Pom Prap Sattru Phai Sampantawong

iii) New Business Area (Area: 138 Km^2):

Pratum Wan Bangk Rak Dusit Phya Thai Thonburi
Klong San Bangkok Nio Bangkok Yai Yannawa

iv) The central business district (CBD) consists of Phranakorn, Pom Prap Sattru Phai, Sampantawong, Pratum Wan, and Phya Thai. Almost 50% of the services and office facilities in the BMR is concentrated in the CBD. Phranakorn holds about 50% of the government employees and offices.

v) Klong San, Thonburi, and Bangkok Noi are high density residential areas.

b) Rapidly Growing Suburban Area (Area: 1,065 Km^2, Population: 3.3 Million in 1990)

i) The area consists of 8 districts of the ABMA and 3 districts of Nonthaburi, surrounding the Central Business Area and being surrounded by the Outer-ring Road.

ii) The ABMA

Residential Area: 183 Km^2
Commercial, Manufacturing, Government Office Area: 71 Km^2
Agricultural Area (Mainly in Phra Khanong and Bang Khen): 208 Km^2
Open land: 229 Km^2
Phra Khanong Khlong toey Prawet Bang Khen Don Muang
Bang Kapi Huai Khwang Cha Tu Chak Lat Phrao Jom Thon
Bang Khun Thian Phasi Charoen Taling Chan Rat Burana

iii) Nonthaburi

Residential Area: 29 Km^2

Commercial and Industrial Area: 13 Km^2
Open Rural Land: 19 Km^2
Nonthaburi Pak Kret Bang Kruai

iv) The area is developed as an area of self-contained communities with employment opportunities, housing, and basic infrastructure.

v) The area is equipped with the following roads:

Viphavadi Rangsit Ngam Wongwan Chaeng Wattana Ram Indra
Lat Phrao Pattanakan Sukhaphiban 1, 2, and 3
Ram Kam Haeng Thonburi-Pak tho Phet Kaesem
Bangkok Noi-Nakhon Chai Sri

vi) These roads are not organically connected by branch and service roads to form an effective network.

vii) The development has been taking place along these major roads in the belt form.

viii) It is relatively easy to get to the western side the Chao Phraya River because of well developed roads. ABMA's building control regulations prohibit urban development of Taling Chan and Phasi Charoen.

c) Industrial Area (Area: 75 Km^2, Population: 1.3 Million in 1990)

i) Old Industry Area concentrated in the three amphoes in Samut Phrakan:

Samut Prakan Phra Pradaeng Bang Pli
Two industrial parks are located in Bang Pli and Bang Pho. Industrial water supply is in sever shortage as the industry develops rapidly. The number of deep wells have been increasing and caused further land subsidence.

ii) New Industrial Area

- concentrated in three amphoes in Pathum Thai
  Pathum Thani Klong Luang Thanyaburi
- concentrated in two amphoes in Samut Sakon
  Samut Sakon Krathum Baen
- concentrated in one amphoe in Nakhon Pathum
  Sam Phran

d) Outer BMR Area (Area: 6,352 Km^2, Population: 1.4 Million in 1990)

i) The area covers the following amphoes and is located around the outside of the Outer-ring Road.

- Four districts of the ABMA
  Nong Khaem Lat Krabang Min Buri Nong Chok
- Four amphoes in Pathum Thani
  Lat Lum Kaeo Sam Khok Lam Lukka Nong Sua
- One amphoe of Samut Phrakan
  Bang Bo
- Four amphoes of Nakon Pathum
  Kampeng Saen Bang Len DonTum Nakhon Chaisri
- Two amphoes in Samut Sakon
  Samut Sakon Bang Phaeo

2.3.4 Three Development Courses of the BMR

There seems to be three possible directions that future development of the BMR will take place.

1) The Direction Toward the Northern Area:

The major development of the area is expected to take place along Route 1 or Rangsit-Wang Noi Road which stretches from the central business district (CBD) of Bangkok to the sourthern part of Ayutthaya and Sara Buri, passing through the Don Muang Airport and Pathum Thani. Route 32 branches out of Route 1 outside of the Outer-ring Road at Bang Pain into Aytthaya. As supporting roads and by-passes of Route 1, the areas are equipped with Route 306 (connecting Nonthaburi and Pathum Thani), Route 305 or Rangsit-Ongkral-Nakhon Nayok Road (branching out to Nakhon Nayok from Route 1), Route 340 (stretching into Supanburi from south to north of the western areas of the Chao Phra Ya River by intersecting Route 3, 4, 338 as a part of the Outer-ring Road).

Inside of the Outer-ring Road, Phahon Yothin Road runs side by side with Route 1 up to the Don Muang Airport and works a major by-pass of Route 1.

Inside of the Outer-ring Road, three industrial parks have been already developed at Nava Nakorn, Mabung Khlong, and Bangkadi, and many more hi-tech related industrial parks have been being developed around the southern hem of Ayutthaya and Bang Pain. Textile, tire, motorcycle, and cement factories have been already constructed in this area.

Negative elements of the Bangkok CBD such as heavy and permanent traffic congestion, rapid increase of land price and office rent, shortage of office space because of the rapid urbanization and business expansion forced some business to move out of the CBD and to create new business districts. The areas near the Don Muang Airport, i.e., the area where Phahon Yothin Road and Route 304 or Chaeng Wathana Road and Raminthra Road intersect are expected to attract some businesses from the CBD.

2) The Direction Toward the Western and South-Western Area:

The major development of the area is expected to take place along three major roads which go into Nakon Pathum and Samut Sakon via the Thonburi district located in the western area of the Chao Phra Ya River. They are Route 4, 338, and 35.

Route 4 or Phetkasem Road goes to Nakon Pathum via Phasi Charoen and Nong Khaem. From Nakon Pathum Route 4 turns down towards south. Route 338 (Bangkok Noi-Nakhon Chaisri Road) goes to Nakon Pathum via Taling Chan. Taling Chan is regraded as a prospective candidate for possible sites of industrial parks once current restrictions on construction are lifted. Route 338 merges with Route 4 at the outside of Nakhon Chaisri.

Route 35 or Thoburi-Pak Tho Road goes to Samut Sakon. Fishery and ceramic industries have been already located in this area. Large fishing bases made this area a center of the fishery industry in Thailand.

3) The Direction Toward the Eastern and South-Eastern Areas:

The major development of the area is expected to take place along three major roads which all eventually go into the Eastern Sea Board (ESB) Area. Route 34 or Bangna-Trad Road goes the ESB via Chonburi. Bang Chan, Bang Pli, and Bang Po industrial parks are located along this road.

The east bound of Route 304 goes to Chachoengsao via Bang Kapi industrial park and Minburi and merges with Route 314 at Chachoensao that goes to Chonburi. The west bound of Route 304 intersects with Route 1 near the Don Muang Airport and Route 306 at Pak Kret; hence, Route 304 connects Nonthaburi, Pathum Thani, and Northern and Northeastern areas of Thailand, and ESB without going through the Bangkok CBD. Route 3 or Sukhumvit Road goes to Chonburi via Samut Prakan. These three roads merge into one at Chonburi.

Samut Prakan was the oldest industrialized province in the BMR. The facilities have been deteriorated and become quite obsolete. They need to be replaced by more modern and efficient facilities. The economic success of the area depends on whether or not the new airport is built and economic activities of the ESB go into the full operations.

2.3.5 Socio-economic Outlook

Future success of Thailand depends on implementation of strategic economic policies and continuation of favorable external conditions. Major external factors are magnitudes of external demands for Thai products, terms of trade, exchange rates of major currencies, oil price, amount of foreign direct investment, and foreign interest rates on Thailand's external borrowings.

It seems that there are three scenarios on the socio-economic outlook of Thailand.

1) Optimistic Scenario (High Case)

a) The external conditions will not change drastically from those of the past few years. Industrial and regional development will progress in a moderate speed. The Thai economy can expect real average annual GDP growth rate of 10% for the next 20 years. The government will increase public sector investment to 8% in 1992 and maintain that level thereafter. The real effective exchange rate will be kept unchanged.

b) The BMR will fairly rapidly grow along with the three directions discussed in the previous section. All the roads / highways are developed as planned to from an effective transportation network and function as a neuro system of the BMR. Basic infrastructure will be developed along major roads. Socio-economic activities will diffuse out towards the outer areas from the CBD.

c) Great improvement in basic infrastructure outside Bangkok and large-scale regional development efforts in the first ranked cities will be made. The Eastern Seaboard area will develop heavy chemical industries by utilizing natural gas produced in the Gulf of Siam and labor intensive export oriented industries. The Southern Seaboard area will develop further through the oil pipeline construction project between the Andaman Sea and the Gulf of Siam. A mild trend of decentralization will emerge. Disparities of growth rates and income levels among regions and industrial sectors will be slightly narrowed.

d) Thailand's competitive advantages as an export base for both foreign and domestic export oriented firms over other ASEAN countries will become stronger by

i) promoting development of manufacturers of parts and components, and intermediate industrial materials for export oriented industries,

ii) promoting development of human resources in the areas of engineers, professionals and middle management personnels.

The BMR, the Eastern Seaboard area and its surrounding areas up to Nakhon Ratchasima, and the Southern Seaboard area around Songkla-Hat Yai will grow into major industrial areas developed around export bases.

e) The political and economic significance of Thailand will increase significantly as the gateway to Laos, Kampuchea, and Viet Nam. Thailand will play a leading role for assisting the economic recoveries of the Indo china countries. Thailand becomes a production base for what they need for the economic recoveries. The Baht based trading zone will penetrate into the Indochina countries. The BMR becomes an information hub of the region.

f) Agro-industries and labor intensive industries will be further developed to exploit the advantage of the availability of inexpensive, but good quality labor workers and richly endowed agro-resources.

2) The Most Likely Scenario (Base Case)

a) Some of the external conditions will go against Thailand but most of them will not change drastically from those of the past few years. Industrial and regional development will progress in a moderate speed. The Thai economy can expect real average annual GDP growth rate of 8% for the next 20 years. The government will increase public sector investment to 7% in 1992 and maintain that level thereafter. The real effective exchange rate will be kept unchanged.

b) The BMR will moderately grow along with the three directions discussed in the previous section. Some of the planned roads / highways are not developed. The BMR still lacks an effective transportation network. Basic infrastructure will be developed along major roads. Some socio-economic activities will diffuse out towards the outer areas from the CBD.

c) Moderate improvement in basic infrastructure outside Bangkok and medium-scale regional development efforts in the first ranked cities will be made. The Eastern Seaboard area will moderately develop heavy chemical industries by utilizing natural gas produced in the Gulf of Siam and labor intensive export oriented industries. Disparities of growth rates and income levels among regions and industrial sectors will be slightly narrowed.

d) Thailand's competitive advantages as an export base for both foreign and domestic export oriented firms over other ASEAN countries will remain unchanged.

Thailand will make moderate efforts in

i) promoting development of manufacturers of parts and components, and intermediate industrial materials for export oriented industries,

ii) promoting development of human resources in the areas of engineers, professionals and middle management personnels.

e) The political and economic significance of Thailand will slightly increase as the gateway to Laos, Kampuchea, and Viet Nam. Thailand will play a leading role for assisting the economic recoveries of the Indo china countries. Thailand becomes a production base for what they need for their economic recoveries. However, the economic recoveries of these countries will be slow. The Baht based trading zone will slowly penetrate into the Indochina countries.

f) Agro-industries and labor intensive industries will be moderately developed to exploit the inexpensive, but good quality labor workers and richly endowed agro-resources.

3) Pessimistic Scenario (Low Case)

a) Most of the external conditions will go against Thailand. Industrial and regional development will progress in a slow speed. The Thai economy can expect real average annual GDP growth rate of 5% for the next 20 years. The government will increase public sector investment to 4% in 1992 and maintain that level thereafter. The real effective exchange rate will also go against Thailand.

b) The BMR will slowly grow along with the three directions discussed in the previous section. Most the roads / highways are not developed as planned. The BMR fails to have an effective transportation network. Basic infrastructure will not be well

developed along major roads. Socio-economic activities will remain mostly within the CBD.

c) Slight improvement in basic infrastructure outside the BMR and small-scale regional development efforts in the first ranked cities will be made. The Eastern Seaboard area will slowly develop heavy chemical industries by utilizing natural gas produced in the Gulf of Siam and labor intensive export oriented industries. Decentralization will not be promoted. Disparities of growth rates and income levels among regions and industrial sectors will not be narrowed.

d) Thailand's competitive advantages as an export base for both foreign and domestic export oriented firms over other ASEAN countries will become weak. Thailand looses out to coastal cities of Southern China and Viet Nam in attracting foreign investment.

e) The political and economic significance of Thailand will decrease as the gateway to Laos, Kampuchea, and Viet Nam because the economic recoveries of the Indochina countries do not go well.

f) Agro-industries and labor intensive industries will be slowly developed by ineffectively exploiting the inexpensive, but good quality labor workers and richly endowed agro-resources.

2.3.6 Population and Households

Although, the BMR is increasing its importance as the main production base of Thailand, its urban population share will decrease from 34 percent to 31 percent by the end of 1996.

Its connection with the emergence of the Eastern Seaboard development and its significance and the hub in the Indochina peninsula make the BMR a city that draws people from other cities. The population as a whole will decline as a result of general decline in fertility rate. The household formation or household structure also changes. Households' type "intact" will be declining, while other type, especially, "single head" and "one person" households will be increasing.

In this study, we apply the population series from the "POPULATION PROJECTIONS FRO THAILAND 1980-2015" done by the Human Resources Planning Division, National

Economic and Social Development Board (June 1991) to be our base line for more detailed forecast down to the Tambon level. Table 2.3.6-1 shows results of estimation for population.

Table 2.3.6-1 Forecasted Population

	1987	1992	1997	2002	2007
BKK Metropolies	5,609,352	6,370,000	6,868,999	7,322,000	7,738,000
Nonthaburi	571,871	656,000	779,000	907,000	1,045,000
Samut Prakan	741,905	852,000	987,000	1,126,000	1,275,000
Pathum Thani	415,193	468,000	538,000	609,000	686,000
Nakhon Pathom	619,518	645,000	703,000	761,000	820,000
Samut Sakhon	334,170	351,000	391,000	432,000	474,000
Ayutthaya	668,611	742,000	804,000	866,000	925,000
BMA Total	7,338,321	8,346,000	9,172,999	9,964,000	10,744,000

2.3.7 Housing Needs and City Growth

The household formations mentioned above induce needs of housing. Nonetheless, not all households can afford for their housing acquisition. It is estimated that housing needs are altogether 70,000 units on average during the 7th Plan period

The housing needs, together with the land price increase in the inner district of the BMA has given rise to the impetus of city expansion both horizontally and vertically. The horizontal city expansion is pushed by the housing development around the BMA fringe area where land price is still not so high. The center of the BMA on the other hand, tends to utilize land area effectively by develop high-rise buildings. They are mostly office buildings, shopping plazas rather than residential condominiums.

The BMR is growing into three directions. The east along the Bangna-Trad road, the west along the Pinkao-Buddamonthon road and the north towards the Ransit road, north of the Don Muang air port. As a matter of fact, the agricultural land area has been decreased by 28,000 rai per year. Most of the new developing (more than 70 percent) areas are more than 20 kilometers away from the city center. Land price of the city fringe has increased 30 percent per year from 1988 as compared with 28 percent per year of the inner city.

High-rise buildings have been concentrated along the Sukhumvit road, Silom and Surawong road, Sathon road, Rama IV road, Rachada Pisek and Rama IX road, Phahon Yothin road (Monument up to Sapan Kwai junction), Pechburi road around the Pratunam area, and around the Pratumwan road as well as the Rachaprasong and Rachadamri road. These are in the inner city area where office buildings are built in response to the demand for office space. Some are

rental apartments and condominiums for foreigners and high income people The average floor space price is 40,000-50,000 Baht per square meter for residential condominiums and 500-600 Baht per square meter per month for rental office space as of 1991 for the modest Pratunam area. The price of land per square wah (4 square meter) is roughly 500,000 - 600,000 Baht along the Silom road may be a reference offered price. As a reference also, in 1988 there were altogether 180 projects of condominiums in the inner city. The floor space has increased by 5.4 million square meters. These are 2.5 million square meters for the office space.

The new families who badly need their own homes may have to acquire them in remote area more than 30 kilometers away from the inner city area, a 1.5 hours by private car on week days and 1 hour on week-ends if they can afford between the house price of 300,000 (condominium) to 1.5 million (single house) Baht in 1991.

In this study, we rely on our estimation of households based on the data collection from Department of Local Administration (DOLA). With assumptions on household sizes given the population series, we arrive at the number of households by provinces. Table 2.3.7-1 shows the results of estimation for the number of households.

Table 2.3.7-1 Forecasted Number of Households

	1992	1997	2002	2007
Bangkok Metro.	1,252,048	1,506,043	1,791,669	2,114,282
Nouthaburi	166,404	220,424	286,427	368,492
Samut Prakan	224,300	289,847	369,040	466,608
Pathum Thani	111,551	141,216	176,034	218,363
Nakhon Phthom	89,023	109,206	132,871	160,546
Samut Sakhon	139,751	167,736	199,955	237,267
Ayutthaya	140,751	167,950	199,213	234,324
BMA	2,123,827	2,602,422	3,155,209	3,799,883

2.3.8 Economic Structure and GDP

The BMR during the 7th Plan period is still the main production base for manufactures. The proportion of value added in the BMR is 51 percent of the total GDP of Thailand (BMR's manufacturing sector shares 67 percent and the BMR's service sector shares 54 percent of corresponding sectorial GDP) during the 6th Plan period will become 56 percent at the end of the 7th Plan. The linkages between the BMR and the Eastern Seaboard and the upper central region in terms of their manufacturing relations will be strengthened.

Foreign direct investment that pours into the BMR is concentrated in the BMA as high as 70 percent of the total investment value, 60 percent of the total promoted firms, employing 60

percent of the total private manufacturing employment and register 80 percent of the total capital investment.

In order to forecast the Gross Provincial Products (GPP) we directly estimated the base year data (1989), cross sectional (73 provinces), of the gross provincial products reported by the National Accounts Division, NESDB. The equation is as follows:

Provincial GDP = f(population, share of manufacture GPP,
share of trade GPP).----------(2.1)

The estimated results of Eq. 2.1 by the least square method is given as follows:

Variable Name	Coefficient	Std. Err. Estimate	t Statistics	Probability of t,
Constant	-5972921.1	2246336.7	-2.6589608	0.0097,
Population	5.4681266	0.1891574	28.907809	0.0000,
Share of Man.	238280.72	82377.431	2.8925486	0.0051,
Share of Trade	524752.22	270477.63	1.9400947	0.0565,

Coefficient of Determination (R^2)	0.938748,
Adjusted Coefficient $\overline{R^2}$	0.936085,
Standard Error of Estimate	6194485,
Degree of Freedom	73.

Given the population series above, and the assumption on the changing structure of share of GDP from the manufacturing sector and service sector we forecast the future level of GDP of each province. Table 2.3.8-1 shows results of estimation for provincial GDP.

Table 2.3.8-1 Forecasted Provincial GDP (GPP) Growth Rate

		Actual	Forecast		
		1987-1989	1992-1996	1997-2001	2002-2007
Bangkok Metro.	Low Case		6.77	5.60	3.43
	Base Case	14.56	8.63	7.55	5.30
	High Case		11.51	10.46	8.31
Nouthaburi	Low Case		6.82	5.74	4.03
	Base Case	22.47	10.64	8.26	7.22
	High Case		14.49	12.23	10.70
Samut Prakan	Low Case		5.38	4.59	4.48
	Base Case	21.07	7.69	6.75	4.96
	High Case		11.15	9.97	8.09
Pathum Thani	Low Case		8.00	6.22	4.48
	Base Case	10.27	9.70	7.95	6.25
	High Case		12.38	10.63	8.96
Nakhon Phthom	Low Case		7.50	6.92	5.15
	Base Case	7.53	9.93	9.24	7.38
	High Case		13.38	12.59	10.63
Samut Sakhon	Low Case		6.13	5.46	3.71
	Base Case	9.96	8.32	7.67	5.93
	High Case		11.51	10.89	9.17
Ayutthaya	Low Case		5.94	4.78	4.03
	Base Case	6.67	8.32	7.67	5.93
	High Case		8.02	6.02	5.05
BMA	Low Case		6.69	5.54	3.50
	Base Case	15.25	8.67	7.53	5.48
	High Case		11.66	10.51	8.46

2.3.9 Employment

The employment of the BMR is computed on the basis of the regression equations. It is estimated by cross-section data. The equation is as follows:

Employment = f(GPP, population, share of manufacture GPP and share of service GPP). ----------(2.2)

The estimated results of Eq. 2.2 by the least square method is given as follows:

Variable Name	Coefficient	Std. Err. Estimate	t Statistics	Probability of t,
Constant	-17063.903	4718.4148	-3.6164483	0.0006,
GPP	0.0059383	9.758 e-05	60.858018	0.0000,
Population	11086.261	4512.2398	2.4569307	0.0166,
Share of Man.	738.12310	155.08727	4.7594050	0.0000,
Share of Service	231.07183	611.51596	0.3778672	0.7067,

Coefficient of Determination (R^2)	0.993741,
Adjusted Coefficient $\overline{R^2}$	0.993373,
Standard Error of Estimate	12560.76,
Degree of Freedom	73.

Table 2.3.9 shows results of estimation for the employment.

Table 2.3.9 Forecasted Employment

	GPP Case	1987	1992	1997	2002	2007
Bangkok Metro.	Low Case		1,906,226	2,577,501	3,301,244	3,881,399
	Base Case	1,122,771	2,000,088	2,945,945	4,131,273	5,329,458
	High Case		2,152,571	3,609,652	5,783,253	8,556,907
Nouthaburi	Low Case		88,553	117,620	150,954	186,674
	Base Case	1,122,771	97,332	150,223	216,195	300,450
	High Case		107,544	195,176	333,669	543,474
Samut Prakan	Low Case		269,579	335,047	405,727	464,795
	Base Case	49,145	286,156	392,246	522,732	655,915
	High Case		311,580	493,901	760,874	1,103,155
Pathum Thani	Low Case		110,464	148,411	191,737	230,961
	Base Case	155,407	114,686	165,298	230,526	301,002
	High Case		121,568	195,556	307,176	454,127
Nakhon Phthom	Low Case		61,562	87,122	119,175	150,122
	Base Case	58,210	66,114	104,690	159,311	222,664
	High Case		72,645	133,885	236,305	382,866
Samut Sakhon	Low Case		65,618	83,592	104,073	120,728
	Base Case	38,318	69,581	97,922	134,914	173,548
	High Case		75,260	121,438	192,923	287,452
Ayutthaya	Low Case		43,427	59,828	77,566	96,295
	Base Case	38,595	45,561	65,735	87,657	111,052
	High Case		49,721	76,201	105,447	138,278
BMA	Low Case		2,374,822	3,178,579	4,049,662	4,763,829
	Base Case	2,450,094	2,498,262	3,653,712	5,100,726	6,586,825
	High Case		2,693,263	4,494,285	7,184,972	10,657,663

CHAPTER 3

TREND OF TELECOMMUNICATIONS TECHNOLOGIES AND SERVICES

CHAPTER 3 TREND OF TELECOMMUNICATIONS TECHNOLOGIES AND SERVICES

3.1 Evolution of Network Digitization

Telecommunications networks have been rapidly digitized by mainly expanding and rehabilitating trunk and transit line sections and toll and transit exchanges so that the merits of digital communications and low price digital communication systems can be exploited. But in the coming years, the network digitization toward ISDN (Integrated Services Digital Network) will be vigorously pursued by network operators to offer new services economically and efficiently.

The digitization toward ISDN has two aims. One is to make telecommunications services easy to use for customers. Another is to make an economical construction and efficient use of telecommunication networks possible.

In conventional telecommunications networks, customers must install separate lines for different services. It is very inconvenient and troublesome for customers to take advantages of various telecommunication services. In ISDN, customers can use various services by one telecommunication network through one user-network interface.

It is expensive to construct individual service-specific telecommunications networks to provide non-voice services. In particular, it is very expensive to install low-utilized subscriber lines because they take a half of telecommunication network construction costs in any service. Therefore, from an economical viewpoint, common-use of a network is necessary for service integration. Due to the development of the LSI (Large Scale Integrated Circuit) technology and optical fiber cable transmission technology, digital transmission of voice messages became more economical than analog transmission. This is a main cause of introduction of ISDN.

The existing telephone networks were constructed on the basis of analog technology, most suitable for transmitting voice messages. In case of digital transmission such as data communication, MODEMs (Modulator and Demodulator) are used. It only allows to transmit data with the speed of approximate 20 kb/s in the voice frequency band. A digital network can transmit data with high speed. The network evolution for digitization toward ISDN is shown in Figure 3.1.

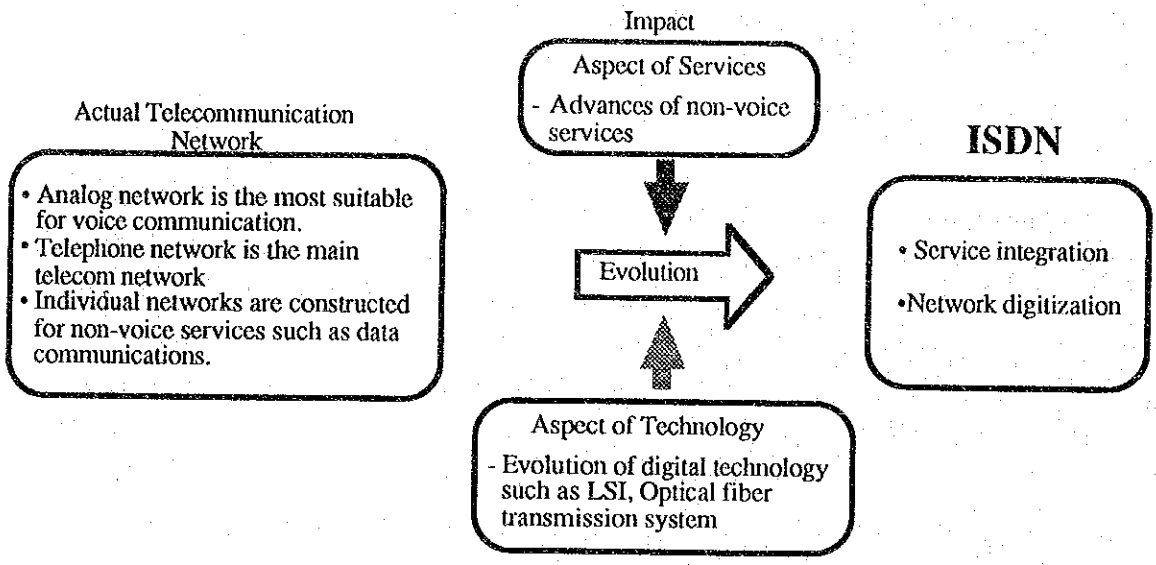


Figure 3.1 Evolution of Network Digitization toward ISDN

3.2 Network Transformation

3.2.1 Network Digitization and Integration

1) Telephone Network

Public telephone networks were initially built with analog technology to transmit mainly voice messages.

2) Formation of Individual Service Networks

It was necessary to build various networks for meeting growing needs for data communications caused by development of computers and related systems. These networks were built as separate systems because different technology was needed to implement different services.

3) Creation of ISDN Using Advanced Digital Technology

Studies to investigate the concept of ISDN were started in the middle of the 1970s, particularly by CCITT. With ISDN, it was envisaged that even subscriber lines would be digitized to allow the provision of a wide variety of services, including voice, image, and date, through a single unified interface.

Incorporating digital technology in telecommunications networks made service and network facility integration possible. Such integration could be achieved because digitized information would allow different services such as telephone and data communications to be provided through the same network.

4) Toward Completion of ISDN

At present, ISDN has reached the stage where subscriber lines have been integrated. However, different facilities are still being used in transmission networks, depending on the communication speeds and modes involved. At this point, it is not possible to provide broadband communications at 150 Mb/s, which is needed to support image communications and other advanced services. There are growing expectations that a broadband ISDN (B-ISDN), built around ATM (Asynchronous Transfer Mode) and optical fiber cable transmission technology, will provide an answer to these service demands.

The advances made in the use of digital technology in the recent years have facilitated a transformation from service specific networks to the formation of ISDN.

3.2.2 Creation of Intelligent Networks

1) Necessity of Intelligent Networks

The more telecommunications services are penetrated into the society, the more diversified and sophisticated network services people demand. The creation of intelligent networks(IN) is one effective approach to cope with these demands in a quick and flexible manner. Incorporating intelligent capabilities in networks will enhance network services as well as operating efficiency.

2) Evolution of Network Services Control

For providing new network services, at first, functions supporting these services were incorporated in each local switch (LS) as shown in Figure 3.2.2-1 (a). After that, the integrated functions were incorporated in toll switches to offer wide network services as shown in Figure (b). This is called the pre-intelligent network (Pre-IN) stage.

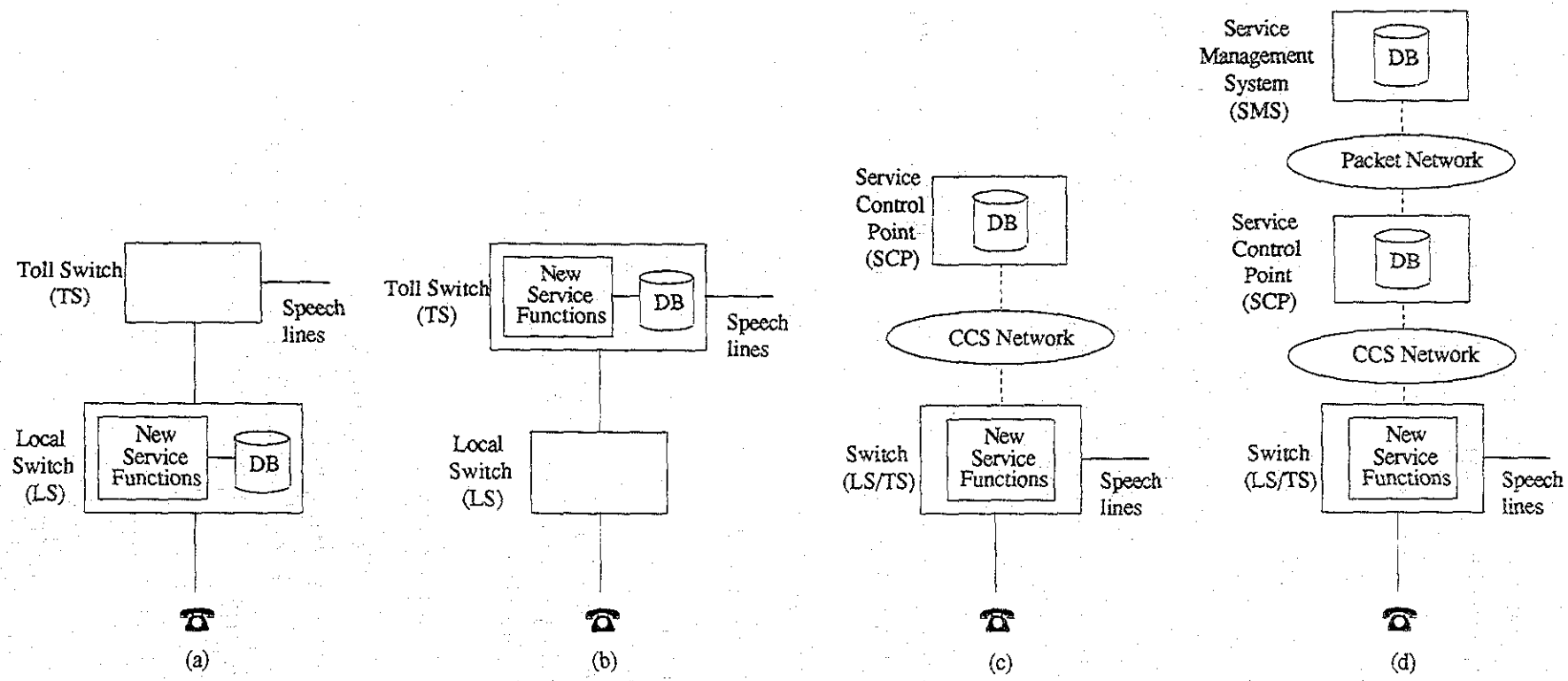
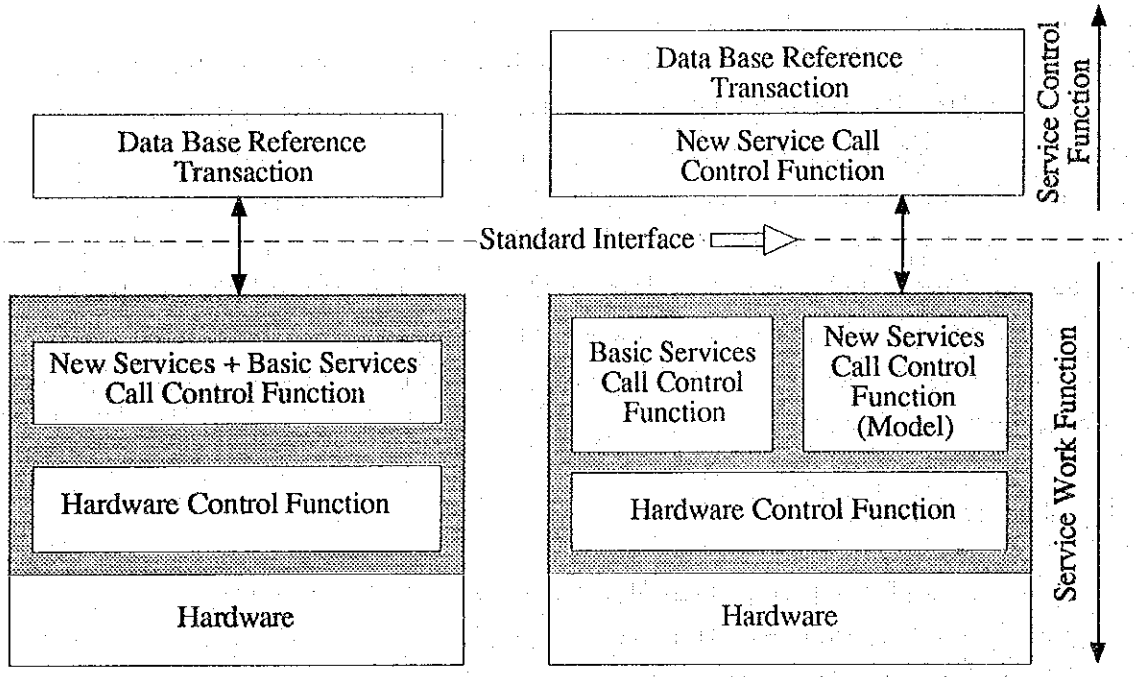


Figure 3.2.2-1 Evolution of Methodologies Supporting New Network Services

In the next stage,the introduction and wide use of the common channel signaling system No.7 network has made it easier to transfer various kinds of signals between switches. As a result, the following becomes possible. Data base supporting service functions and services are established independently from switches as shown in Figure (c). Independent nodes like this are called service control points (SCP) (or network service control points:NSP). Service management systems (SMS) (or network service control support points: NSSP) supporting the reception of service requests are established separately from switches to make it much easier to add new network services as shown in Figure (d). The network composed of SCPs or SMSs is called an intelligent network.

3) Advanced Intelligent Network

In an intelligent network, controlling functions supporting new network services are incorporated in switches. When new network services are added, it is necessary to incorporate functions in not only SCPs and SMSs but also in softwares of switches. All the functions supporting call control for new network services are incorporated in SCPs. New network services are realized by switches controlled by SCPs. The network in this stage is called an advanced intelligent network (AIN). The switches are called service switching points (SSP) (or Service Access Points:SAP). They only play receiving roles to offer new network services. The structure of an AIN is shown in Figure 3.2.2-2.



(a) Conventional System (b) Advanced Intelligent Network (AIN)

Figure 3.2.2-2 Structure of Advanced Intelligent Network

At present, the study on standardization for interface between modeled SCPs and SSPs is making a progress in CCITT. This study is for telephone networks and N-ISDN. The study on standardization of an AIN for B-ISDN will be initiated in the next XI session (1993-1996) in CCITT.

3.3 Service Trend

Toll free dialing services such as the Free Dial service (0120) in Japan and the 800 service in the United States are known as representative network services, supported by intelligent networks. From now on, various kinds of network services will be demanded as customers' needs become more sophisticated.

Broadband communications have been studied by SG XVIII in CCITT so that network operators can provide various services in accordance with customers' needs. The schedule of the study is as follows:

Release 1 (Recommendation in 1992)

- ATM leased line services
- Communication services in LANs
- Point to point switching services(image), etc.

Release 2 (Recommendation approximately in 1994)

- Multipoint switching services
- multi-quality services,etc.

Release 3 (Recommendation after 1996)

- Broadcasting type services
- Quality change in communication, etc.

3.4 Supporting Technologies of ISDN

3.4.1 Optical Fiber Cable Transmission

1) Structure of Optical Fiber Communications

Optical fiber communications consist of three basic elements, optical sources, optical detectors and optical fiber cable as shown in Figure 3.4.1-1.

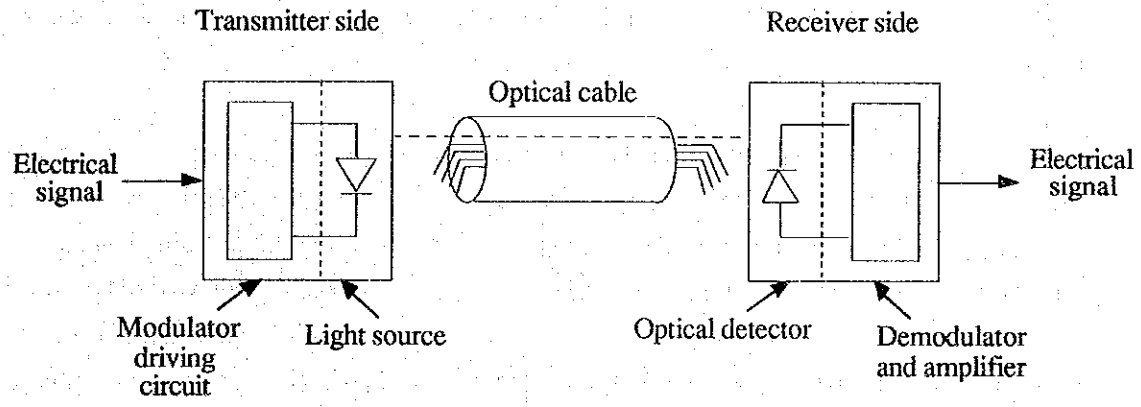


Figure 3.4.1-1 Fundamental Optical Communications

Research on light emitting elements began in the 1960s with the discovery of the ruby laser diode. In 1972 the semiconductor diode was developed, capable of continuous oscillation at the room temperature. In 1975 the distributed feedback(DFB) semiconductor laser diode was developed to emit light with extremely pure wavelength. Semiconductor lasers are tiny, consume electricity only sparingly, and overcome the problem of early fade-out by achieving a life expectancy of more than ten years. They soon became the main optical source for optical transmission systems.

The compact photodiode with high quantum efficiency was developed as an effective light receiving element. The avalanche photodiode (APD), which takes the advantage of the avalanche effect, was able to achieve improved sensitivity.

Optical fiber suddenly became practical as a medium in the 1970s when loss was reduced to 20 dB/km by Corning Corporation in the United States. By 1976 this was lowered to just 0.5 dB/km(at a wavelength of 1.3 mm), and by the 1980s to 0.2 dB/km(at a wavelength of 1.55 mm) as fiber manufacturing techniques were perfected and commercialization of fiber transmission systems became possible.

The rapid improvements in these optical devices and optical fiber have created the present large capacity systems and increased the interval length between repeaters.

2) Expanding Role of Optical Fiber Communications

From the standpoint of application areas for optical fiber communications, the next target is to realize optical subscriber loops (i.e.,fiber to the home). In going from the present telephone network to B-ISDN, optical fiber lines are to be introduced in entire subscriber loops.

As for future optical fiber communications technology, the next generation system should feature greatly improved photodetector sensitivity and employ frequency division multiplexing(FDM) to achieve even larger capacity as coherent optical transmission and direct optical amplification technology are established. These advances will make long-span repeaterless transmission in the trunk line system possible. These in subscriber loops will also enable optical switching and branching. It will then become possible to offer broadband digital services and a wide range of other new telecommunication services. Future outlooks for optical transmission technology are shown in Figure 3.4.1-2.

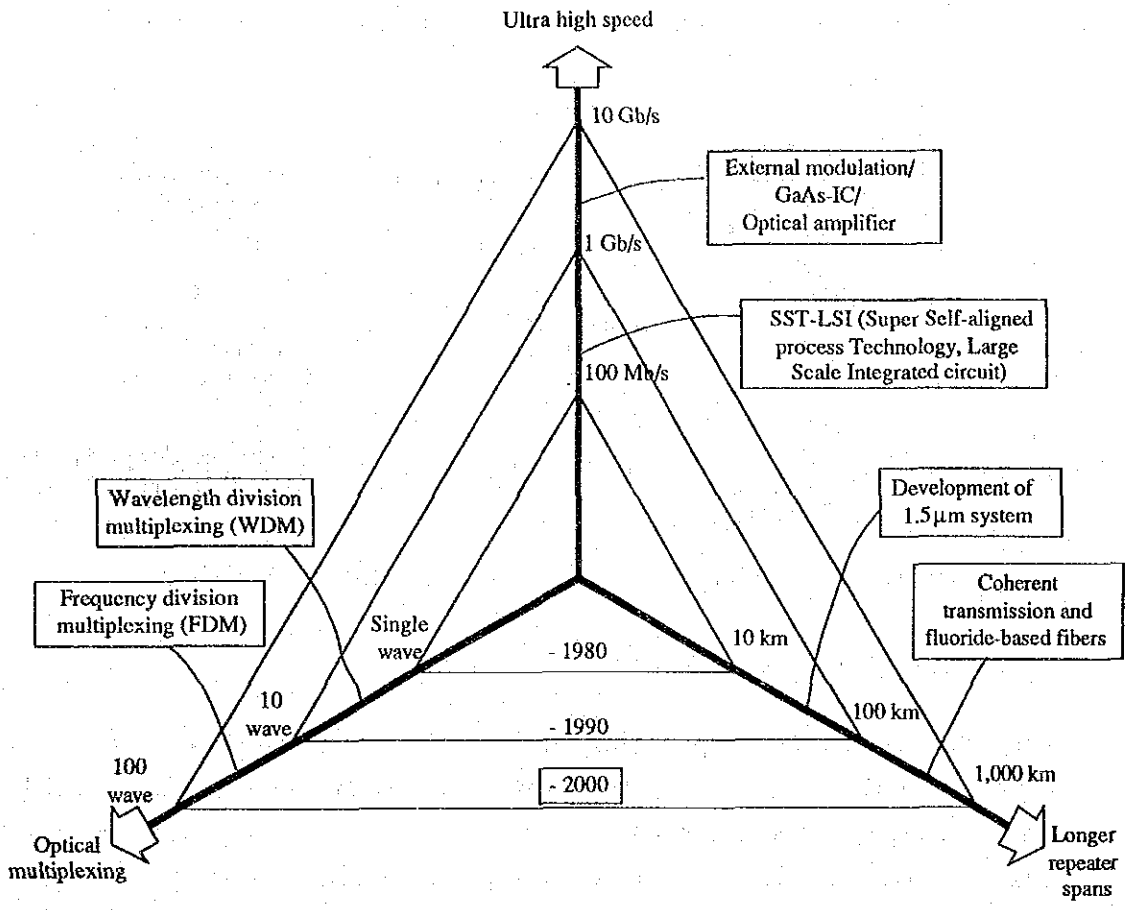


Figure 3.4.1-2 Future Outlook for Transmission Technologies

3.4.2 High-speed and Broadband Switching System

1) Technology Trend

Development of high-speed and broadband switches are key to realize B-ISDN. This development has two trends. One is the trend of packet switching technology such as the asynchronous transfer mode (ATM) switch. The other is the trend of circuit switching technology such as an optical switch employing the synchronous transfer mode (STM).

Broadband communication services will be developed, for the time being, for business communications from the standpoint of its cost and use. For this purpose, ATM switches being suitable for multimedia communications are promising. In the next step, it is necessary to consider how to penetrate image communications services into households. For this, its cost must become lower, and its needs must be marketed. There will be a possibility of introduction of multichannel and high definition CATV services. This is realized by installing optical fiber lines in transmission sections. The key is how economical this can be realized. This issue will be resolved by optical switches. This is a

plan of integrated communications and broadcasting networks. This development is shown in Figure 3.4.2-1.

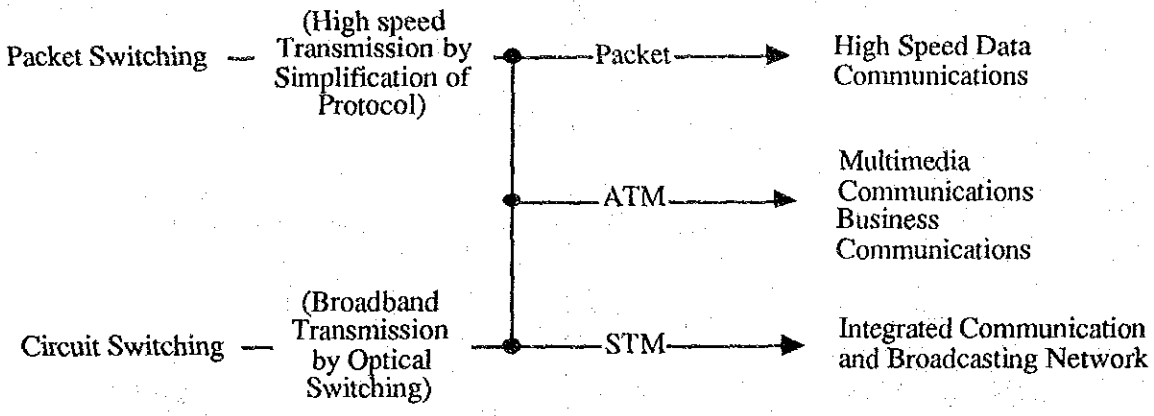


Figure 3.4.2-1 Approach to High Speed and Broadband Switching

2) Asynchronous Transfer Mode Switch

One of the most promising approaches for B-ISDN is the asynchronous transfer mode (ATM), which is a system recommended by CCITT. The ATM can be characterized by its very high-speed transmission links and simple hard-wired protocols within a network. In an ATM network, information such as voice, data and video is divided into fixed length data blocks, called cells. These cells are asynchronously transmitted through the network.

A cell consists of a header housing that controls information for cell transmission and an information field housing that transmits data. Identification of logical channels in circuits is executed by labels in the header. Data communication speed is freely changeable by increasing or decreasing the number of cells which have the same labels in accordance with information volume. A target of maxim communication speed for ATM switches is more than 150 Mb/s.

3) Optical Switch

Optical fiber communication systems have been used only for transmission so far. But recently research and development of optical switches are making a progress according to the progress of optical devices such as optical switch elements, optical memory and optical logical elements. There are a few optical switching system types such as space division optical switching, time division optical switching and wavelength division switching systems. At present, it is reported that a time division optical switching system with speed of 128 Mb/s x 4 = 512 Mb/s is in the experimental stage.

3.4.3 High-speed Transmission System

1) Digital Hierarchy

Synchronous digital hierarchy (SDH) supported by the synchronous multiplexing technology was recommended by CCITT in 1988. This hierarchy is regulated as a network node interface (NNI) (155.520 Mb/s) with a frame structure to multiply easily both 1.5 Mb/s system used in Japan, North America and 2 Mb/s system mainly used in Europe. Transmission line speed is always selected at the NNI signal speed (n x155.520 Mb/s) due to realization of technology and demands. At present, n=1, 4 and 16 (155.520, 622.080 and 2488.320 Mb/s) are regulated by CCITT. Digital hierarchy is shown in Figure 3.4.3-1.

In SDH, a virtual container multiplexing system is utilized as a new multiplexing system which has the following features:

i) It is capable to multiplex efficiently various signals, ranging from 64 Kb/s to high-speed and broadband,

ii) It is a international standard system which uniformly copes with 1.5 Mb/s system and 2Mb/s system,

iii) It has advanced capabilities of operation, maintenance and management for networks.

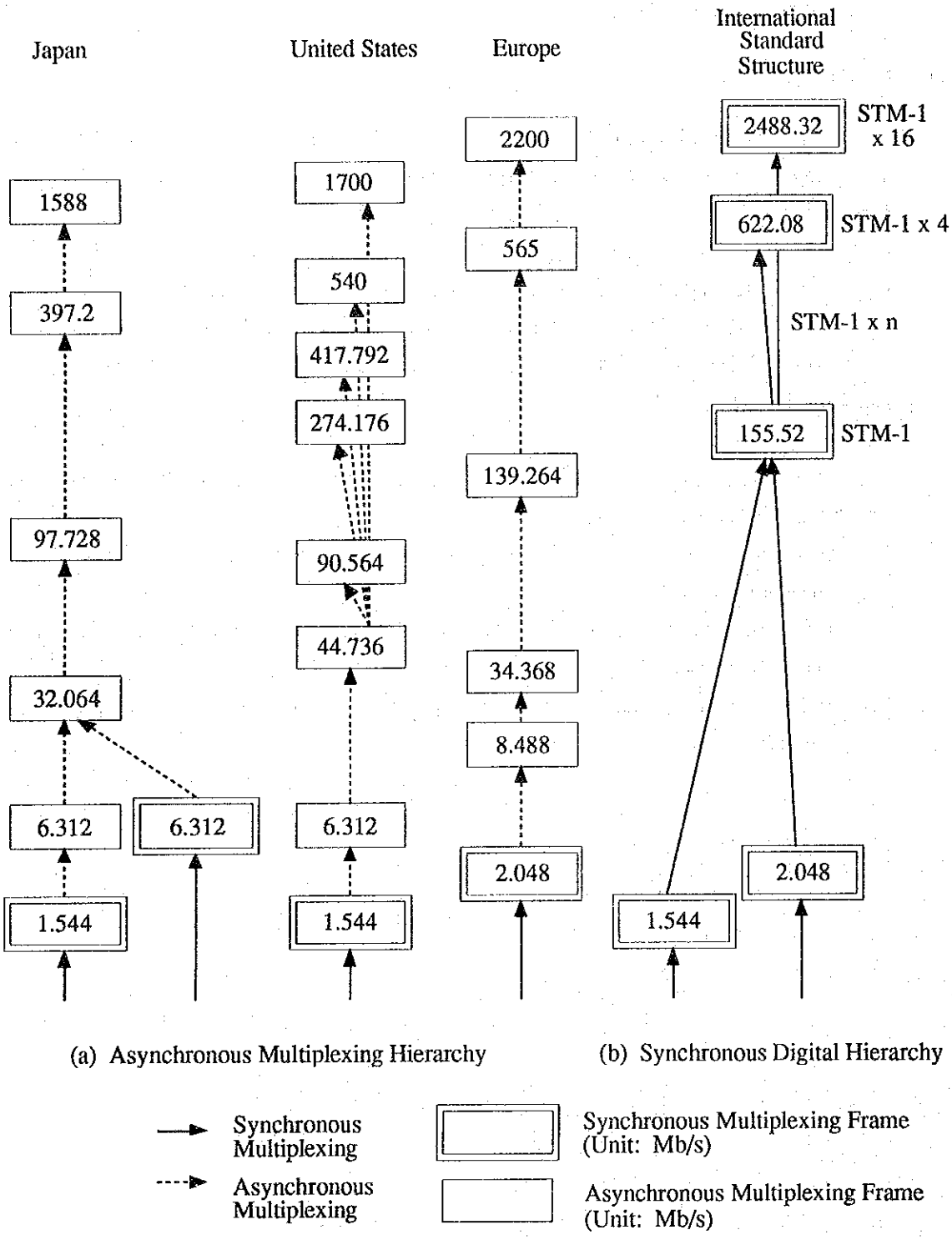


Figure 3.4.3-1 Digital Hierarchy

2) Digital Microwave Radio (DMR) Transmission System

a) Capacity and Synchronous Digital Hierarchy (SDH)

A rapid progress has been observed around the world in the development and implementation of DMR since it was first put into service in 1969. The driving force for increasing capacity was supported by the migration to higher-order modulation systems and improved spectral efficiency, development that have permitted increased throughput. At the same time, route development costs have fallen. Progress during the brief history of commercial DMR has been marked by advances in higher modulation schemes - 4PSK (Phase Shift Keying), 8PSK, 16QAM (Quadrature Amplitude Modulation) and 64QAM - so that now the most advanced working systems employ 256-QAM. DMR is used extensively together with optical fiber networks by many nations.

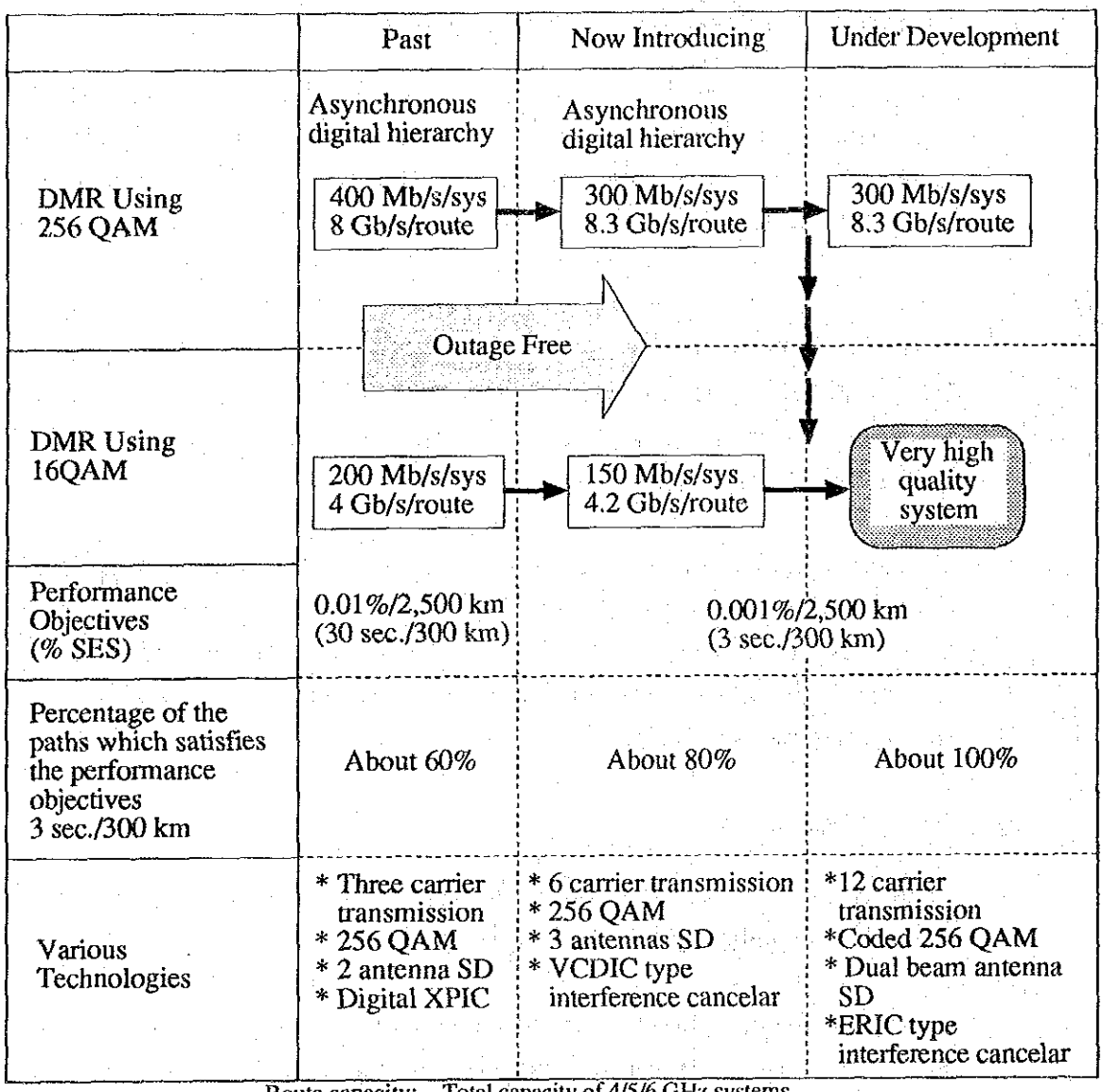
The current focus for introducing new radio systems is DMR that is compliant with the new synchronous digital hierarchy. The new SDH realizes significant advantages. It will permit capacities up to 52 Mb/s and even 156 Mb/s, stable and easy multiplexing and cross-connection, and contribute to simple and flexible network construction.

b) Quality Enhancement

As ISDN and digital leased line services have become more and more popular, user demands were pushed up for better quality circuits.

Implementation of higher-order modulation schemes on radio links achieves better spectral efficiency. It also reduces the system immunity to noise and signal distortions. The migration to higher-order modulation must be, therefore, accompanied by enhanced countermeasures to reduce the effects of impairments due to severe fading.

Unquestionably the main factor causing degradation of DMR characteristics is multipath fading, a phenomenon that diminishes power on the receiving side and degrades the spectral characteristics. The former impairment increases thermal and interference noise, and the latter causes an increase in waveform distortion. The newly developed technology such as robust modem technology, sophisticated interference canceling, automatic transmitting power control, dual-beam antennas, and multidimensional diversity reception will create more reliable DMR systems. Figure 3.4.3-2 shows the developing status of the DMR.



Route capacity: Total capacity of 4/5/6 GHz systems

XPIC: Cross paralyzation interference cancelar
VCDIC: Vector correlation detection type interference cancelar
ERIC: Extraction and Re-inejction type interference cancelar

Figure 3.4.3-2 Developing Status of the Digital Microwave Radio (DMR)

3.4.4 Mobile Telecommunications

1) Introduction

a) Personal Communications

To call someone by using conventional wire facilities, it is necessary to dial the number of the station to be called such as an office or a home. By personal communications, a cellar can, however, reach a called party regardless of the location. This can be accomplished by assigning every person a unique number that will serve as a personal telecommunication number (PTN).

One approach to give every person this personal communications capability is to let everyone carry around a portable radio phone. A second approach is to use stationary telephone equipment. In the latter case, when a person moves to a different location, he must inform his personal telecommunication number to the network . Any telephone call to that personal telecommunication number would be automatically routed to a nearby telephone. This method is referred to as "tracking communication" or "tracking exchange".

CCIR defined these two types as follows:

Mobile Network Mobility
Mobility involves the ability of a user to be in continuous motion (including stationary condition) while using telecommunication services. This requires the telecommunication services to be available at everywhere and in anytime.

Fixed Network Mobility
Mobility is conferred by access flexibility to telecommunication services, which are available at discrete locations, in such a way that the user identifies with, and may configure, any one of these fixed terminals to meet his requirements. These requirements may then be relocated from one terminal to another terminal without restriction or extension. Figure 3.4.4-1 shows the PTN concept.

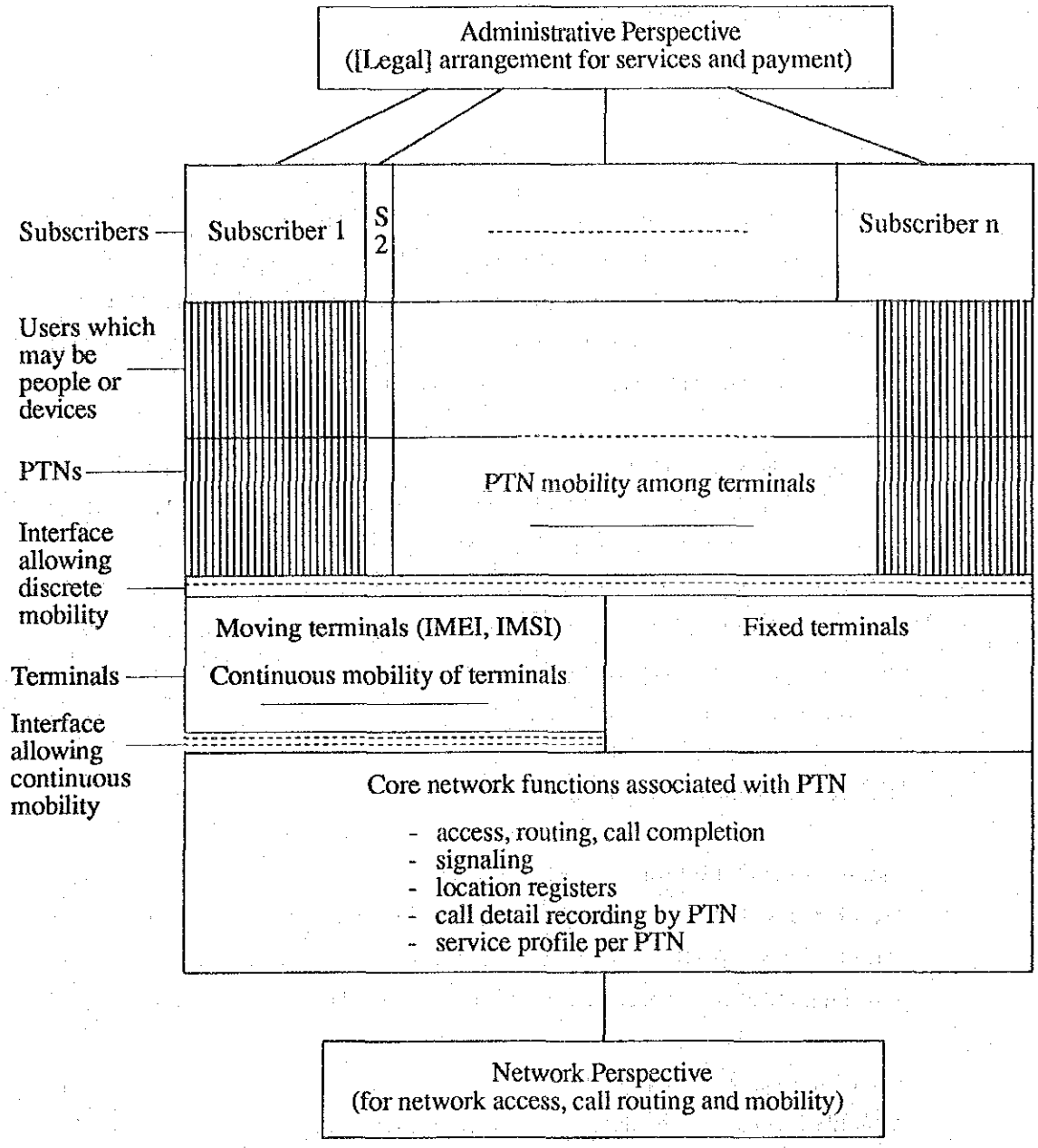
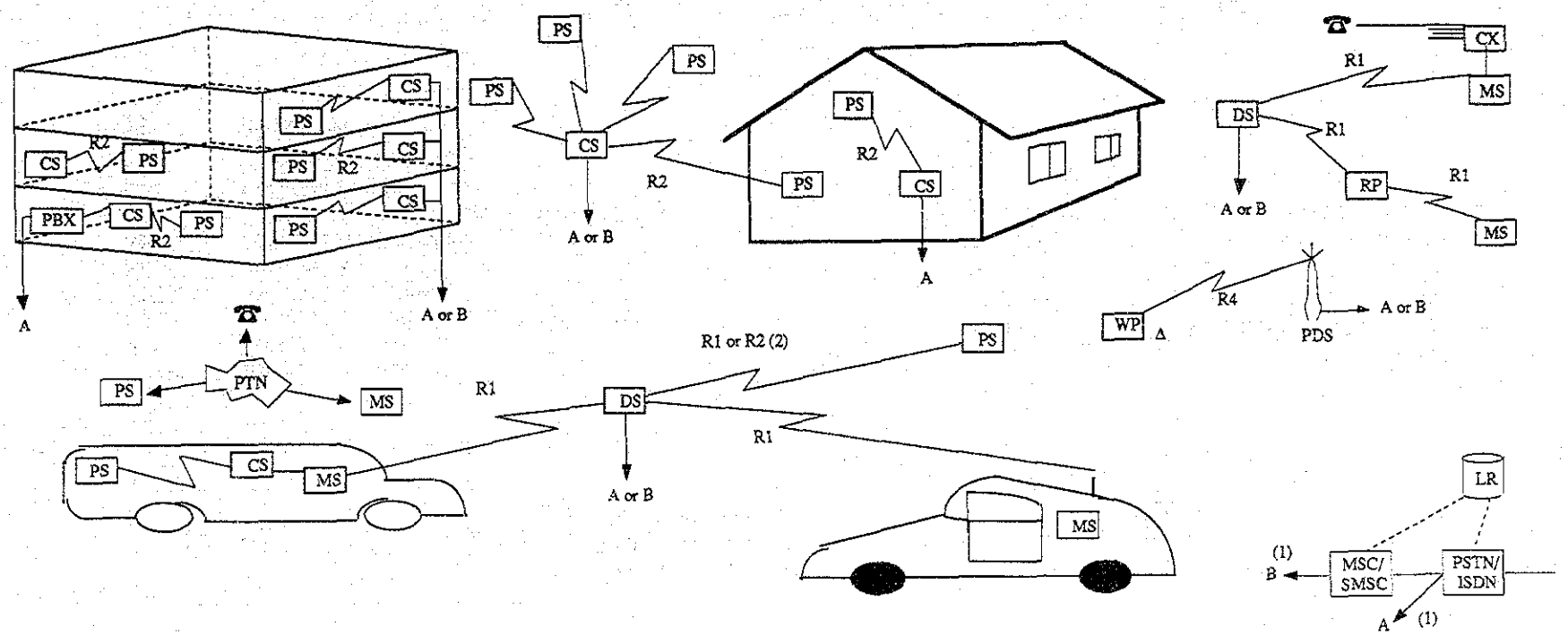


Figure 3.4.4-1 The Personal Telecommunication Number (PTN) Concept



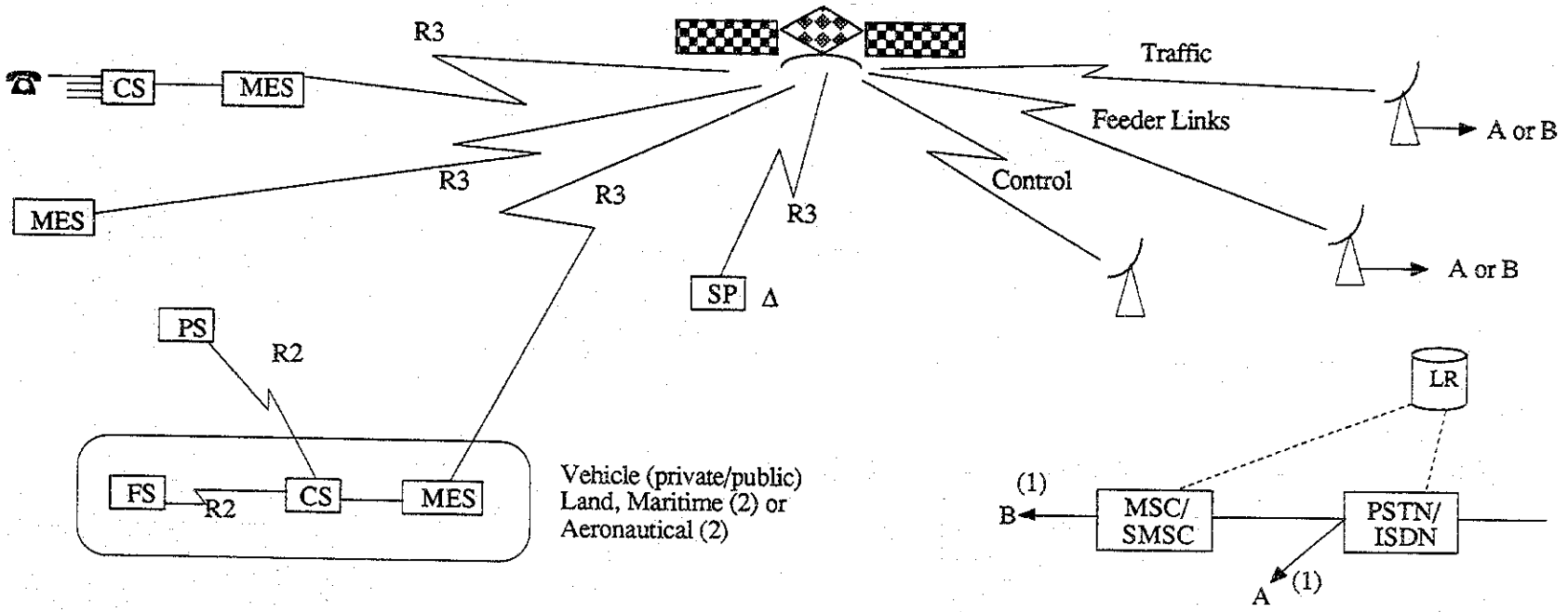
R1-R4:	Radio Interface
PS:	Personal Station (R2)
CS:	Personal Base Station (Cell Site for PSs)
MS:	Mobile Station (R1)
DS:	Base Station (for MSs)
MSC:	Mobile Services Switching Centre
SMSC:	Satellite Mobile Services Switching Centre
LR:	Location Register
CX:	Small Rural Exchange, etc.
RP:	Reporter
PTN:	Personal Telecommunications Number Service Paging Base Station Wide Area Power (R4)
☎	Telephone

Note (1): Access to and the scope of the location registration functions will vary with system evolution and network operator requirements. This is reflected in network interfaces A and B.

Note (2): In some implementation scenarios R1 may equal R2.

Δ : Can be co-located/integrated with the PS.

Figure 3.4.4-2 Scenario for Personal Communications with FPLMTS (Terrestrial Component)



R1-R3:	Radio Interfaces
PS:	Personal Station (R2)
CS:	Personal Base Station (Cell Site for PSs)
MES:	Mobile Earth Station
SP:	Satellite Pager (R3)
MSC:	Mobile Services Switching Centre
SMSC:	Satellite Mobile Services Switching Centre
LR:	Location Register
CS:	Small Rural Exchange, etc.
☎	Telephone

Note (1):	Access to and the scope of the location registration functions will vary with system evolution and network operator requirements. This is reflected in network interfaces A and B.
Note (2):	Terrestrial based systems have different radio interface requirements from R3 which need to be considered.
Δ:	Can be co-located/integrated with the PS.

Figure 3.4.4-3 Scenario for Personal Communications with FPLMTS (Satellite Component)

b) Portable Phones

The mobile telephone is a typical example at present of a radio-based telephone instrument. However, tracking a fast moving vehicle requires expensive equipment. Moreover, the available frequencies within a given unit area are limited. This limitation makes it impossible to increase the number of subscribers in any given area. Consequently, if more than ten million portable phone users are to be accommodated in the future, it will be necessary to develop a totally new system that can radically improve frequency utilization efficiency. It is expected that "pocket telephones" can provide this desired improvement.

Pocket telephones adopt the so-called micro-cell system in which the spacing between terrestrial antennas can be reduced to a distance of 100 to 300 meters. It is also assumed that pocket telephones will not be carried around at any faster than the normal human walking speed. As a result, this system will make low transmitting and receiving power levels miniaturized, equipment cost reduction and improved frequency utilization efficiency possible.

c) Tracking Exchange

Using pocket telephones alone for twenty-four hours a day is not very convenient. Therefore, we think it will be necessary to use the second approach to personal communications, namely, the tracking exchange method using stationary telephone equipment.

In the simplest form of the tracking exchange, a user will register his personal telecommunication number and that of a nearby telephone station when away from his office or home. Any call to that person will then be forwarded to the registered number. It is expected that this service will be made available within one to two years. In a future scenario, it is anticipated that calls will be made both to a station number, attached to a particular location, and to a personal telecommunications number, attached to a person.

Moreover, in the 21st century we expect to see a variety of advanced personal communication services that will allow more options for efficient call connections according to individual needs.

2) Future Public Land Mobile Telecommunication Systems (FPLMTS)

CCIR has been studying the future public land mobile telecommunication systems by considering system compatibility necessary for international links and commonality to ensure the reduction of overall systems cost per mobile user.

CCIR's concept on FPLMTS is shown in Figures 3.4.4-2, 3. Examples of the equipment are shown in Table 3.4.4-1.

Table 3.4.4-1 Example of the Characteristic for Personal Communications within FPLMTS (High Density Area)

Characteristics	Type of Station		
	Mobile	Personal Station (PS)(1)	
Cell Plan	MS Outdoor	PS Outdoor	PS Indoor
Cell Area	(min) 0.5 - 1 km^2	(type) 16000 m^2	(type) 600 m^2
Base Station Antenna Height	50 m	< 10 m	< 3 m(2)
Service Area Reliability	90%	> 90%	99%
Base Station Installed indoor/outdoor	No/Yes	Yes/Yes(3)	Yes/Yes(3)
Voice traffic per station Non-voice traffic per station(5)	0.10 E 0.05 E	0.04 E 0.004 E	0.20 E 0.11 E
Voice traffic per km^2 Non-voice traffic per km^2	500 E 82 E	1500 E 150 E	20000 E(4) 5000 E(4)
Blocking	2%	1%	< 0.5%
Station(5) Volume Weight Highest Power	Vehicle mounted or portable 5 W	< ~ 200 cm^3 < ~ 200 g 50 mW	< ~ 200 cm^3 < ~ 200 g 10 mW

Note:
(1) The same PS provides access to cell plans PS outdoor and PS indoor, and also to cell plan MS if MS and PS have the same radio interface (i.e. R1 = R2).
(2) Or leaky feeder
(3) Usual case
(4) Per floor
(5) A range of terminal types will be available to suit operational and user requirements.

Note in the figures: Radio Interface

R1: the radio interface between a mobile station (MS) and the base station (BS)

R2: he radio interface between a personal station (PS) and the personal base station (CS)

R3: the radio interface between the satellite and the Mobile Earth Station (MES). FPLMS may also allow for the automatic routing or traffic between terrestrial and mobile satellite systems

R4: an additional radio interface used for alerting (e.g. paging) in the case of a call which is terminated at an FPLMTS terminal.

3) Trends for Personal Communications

a) Introduction

There would be two main approaches in the world to realize personal communications by radio phones. One approach is to use digital and micro-cell technology for the existing cellular systems to maximize the frequency utilization. Second approach is expansion of cordless telephone systems. Both approaches are not technically much different, however, the second one uses rather simple technology to establish economical systems. Figure 3.4.4-4 shows future application areas of the two approaches.

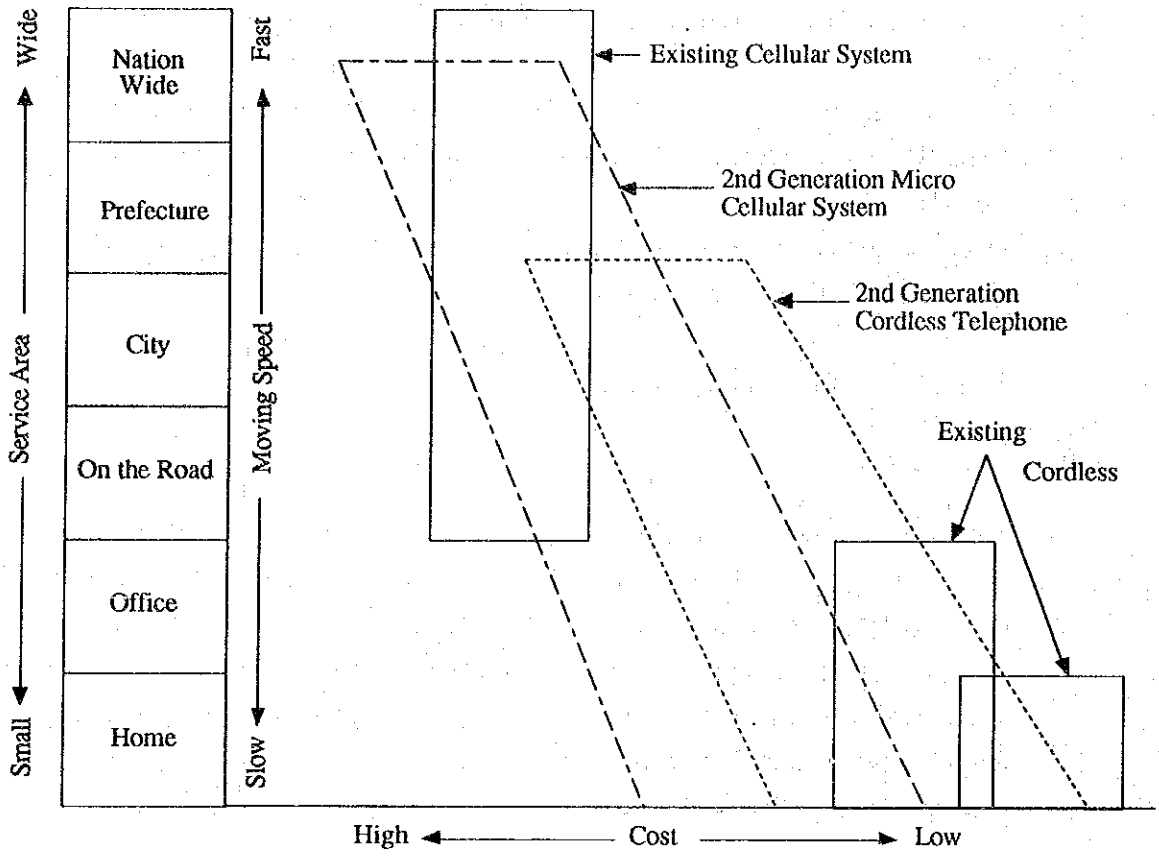


Figure 3.4.4-4 Application Area

b) Cellular System

Cellular system subscribers in the world have been rapidly growing and exceeded 10 millions at the end of 1990. The demand for cellular services will continue to expand until the end of the century; however, the frequency spectrum limitation prevents the subscribers from growing. Digitized cellular systems are introduced or planned to be introduced in many countries to maximize the frequency utilization and to satisfy the requirements of ISDN. Micro-cell technology are also effective to increase the subscriber accommodation capacity.

The propagation range for radio waves depends on various factors such as transmission output level, antenna shape and geographical conditions. With a lower output level, the service area covered by one base station can be used repeatedly within several different zones. The number of available circuits throughout that area can be increased. Digitization improves the interference characteristics. That also achieves the frequency reuse in short distance. For example, 3 cells/9 sectors repeat pattern, 7 cells/21 sectors or 4 cells/24 sectors patterns used in analog systems, are available in GSM (Group System for Mobile Communications) systems.

U.K. is planning to introduce Personal Communications Network (PCN) which use GSM specifications and micro-cell technology. Table 3.4.4-2 shows the configuration of digital cellular and PCN systems.

Table 3.4.4-2 Digital Cellular System and PCN

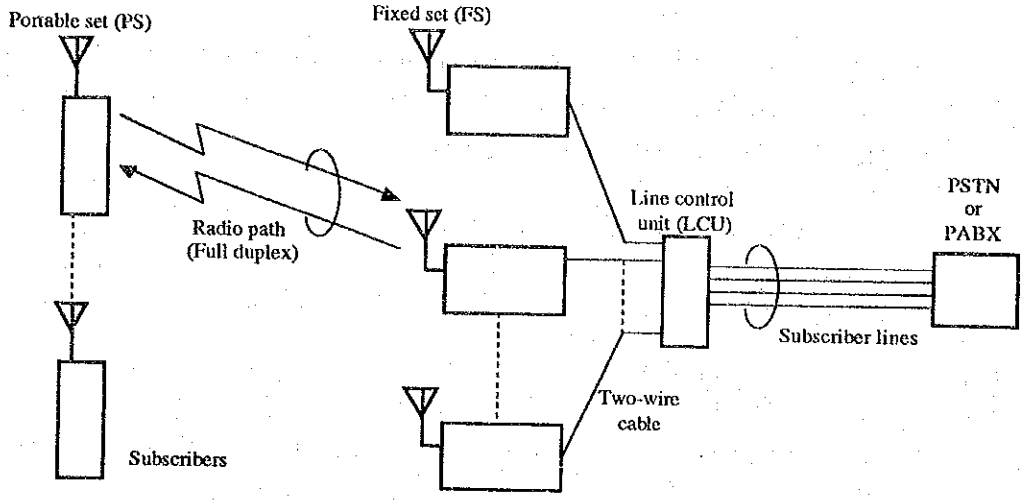
	GSM/Europe	U.S.A.	Japan	PCN/U.K.
Frequency band	935-960 MHz 890-915	869-894 MHz 824-849	800 MHz 1.5 GHz	1.7 to 2.3 GHz
TX-RX separation	45 MHz	45 MHz	130/48 MHz	same as GSM
Carrier separation	200 KHz	30 KHz	25 KHz	ditto
Cell radius	0.5 to 35 km	0.5 to 20 km	0.5 to 3 km or more	0.4 to 6 km
Transmission method	TDMA	TDMA	TDMA	same as GSM
Channel/carrier	8 CH	3 CH	3 CH	ditto
Bit rate	270.833 Kb/s	48.6 Kb/s	42 Kb/s	ditto
Modulation method	GMSK	QPSK	QPSK	ditto
Coding method	RPE-LTP 22.8 Kb/s	VSELP 13 Kb/s	VSELP 11.2 Kb/s	ditto

Note: VSELP: Vector Sum Excited Linear Prediction
Specifications of PCN and USA systems are under developing.
CDMA (code division multiple access) also under study in USA.
GSM: Global System for Mobile Communications
PCN: Personal Communication Network
TDMA: Time Division Multiple Access
RPE-LTP: Regular Pulse Excitation with Long Term Prediction

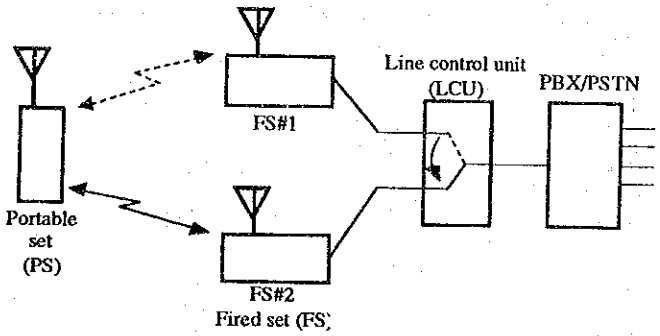
c) Cordless Telephone

Cordless telephone systems, which are conventionally composed of one or several portable set(s) with one fixed set and connected to a telephone extension line, provide services within restricted areas such as inside of a home or an office. It uses simpler radio technology compared with cellular systems and is economical.

The functions of cordless telephone systems are increasing. For example, the NTT business cordless telephone system has the functions that can provide location registration, hand over and enhanced paging services as shown in Figure 3.4.4-5. It can work like a small cellular system.



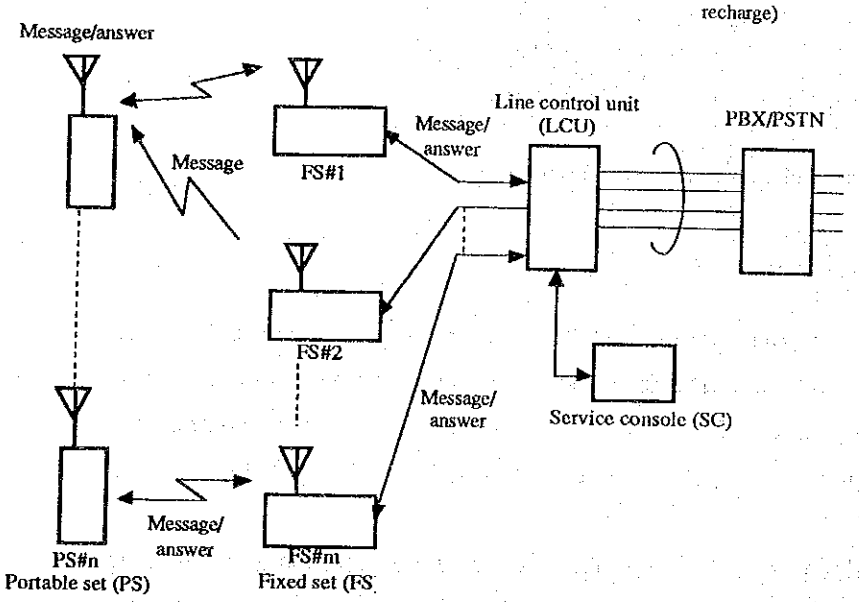
System Configuration of the ACTY



Hand-over Function

Specifications of the ACTY

Radio Frequencies	250 MHz (PS-FS)/ 380 MHz (FS-PS) band
Channels	89 CH
Channel Spacing	12.5 kHz
Modulation (Voice)	PM
Modulation (Control signal)	MSK-FM
Radiated Power (Fixed and portable sets)	10 mW
Radio Zone Radius	50 - 100 m
Volume	370 cc
Weight	350 g
PS Batteries	Ni-Cd: capacity 400 mAH
Operating Time (Without battery recharge)	1.5 hours of transmitting (plus 46 hours of stand-by)



Enhanced Paging Function

Figure 3.4.4-5 An Example of Cordless Telephone

Some countries have already introduced cordless telephone systems for public use. U.K. developed the Cordless Telephone 2 (CT-2) system. It is called "telepoints". The public telephone service was started in 1989. Subscribers can originate calls within 50 to 200 meters from base stations which are installed along with streets. However, the system can not receive calls and uses common air interface (CAI) which can be used in different operators' service areas. The system failed to become popular by these reasons. Some countries will introduce an improved CT-2 system which adds a paging function to CT-2.

New digital cordless telephone systems for public and private use are being developed in many countries, Table 3.4.4-3 shows those.

Table 3.4.4-3 Digital Cordless Telephone Systems

	CT-2/U.K.	DECT/Europe	Japan	U.S.A.
Frequency band	864.05-868.05 MHz	1.8 GHz	2.6 GHz	About 20 companies are testing CT and PCN systems.
Transmission method	FDMA/TDD	TDMA/TDD	TDMA TDMA/TDD	Also testing CDMA
Modulation method	GMSK	GMSK	QPSK GMSK	
Channel number	40 (total)	16/carrier	3 to 8/carrier	
Bit rate/channel	32 Kb/s ADPCM	32 Kb/s	16 Kb/s 32 Kb/s	
Transmit. power	10 mW	250 mW	250 mW	100 mW
Service area	50 tp 200 m	30 to 200 m	about 200 m	

Note: Specifications are under developing except CT-2 system.
FDMA: Frequency Division Multiple Access
CDMA: Code Division Multiple Access
TDD: Time and Direction Division
ADPCM: Adaptive Differential Pulse Code Modulation

3.4.5 Satellite Communications System

Satellite communications systems are rapidly developed for domestic and international telecommunications uses because they have the following features. Costs are insensitive to distance. They are not affected by terrestrial disasters. They are flexible in circuit assignments.

For example, 150 thousand VSAT systems have been used in North America for transportation, hotel, and financial services.

Geostationary satellites are mainly used for telecommunications media because of the following advantages:

* Earth stations are easy to track,
* Twenty four hours communications are even possible by only one satellite,
* One satellite can cover a fairly wide area, and three satellites can cover the whole world.

However, low earth-orbit satellites are proposed for mobile satellite systems to reduce transmission power and antenna sizes of mobile equipment.

1) Fixed-Satellite Service Trend

Technology trends of satellite communication systems are as follows:

a) Increase launching capacity

DELTA (McDonnell Douglas), ATLAS CENTAUR (General Dynamic) and TITAN (Martin Marietta) rockets of United States are available to launch 2 ton level communication satellites. In Europe, ARIAN-4 rockets have been able to launch 2 ton level satellites since 1989. Japan also plans to launch 2 tons level satellites by H-II rockets in 1993.

b) Increasing satellite size and power

The most used communication satellite size was about 600 Kg in the early 1980s, however, in the late 1980s the satellite size increased by about 1.5 tons to 2 tons. These large scale satellites can contain a large number of transponders and increased radiation power. Figures 3.4.5-1 and 2 show the trend of satellite size and radiation power.

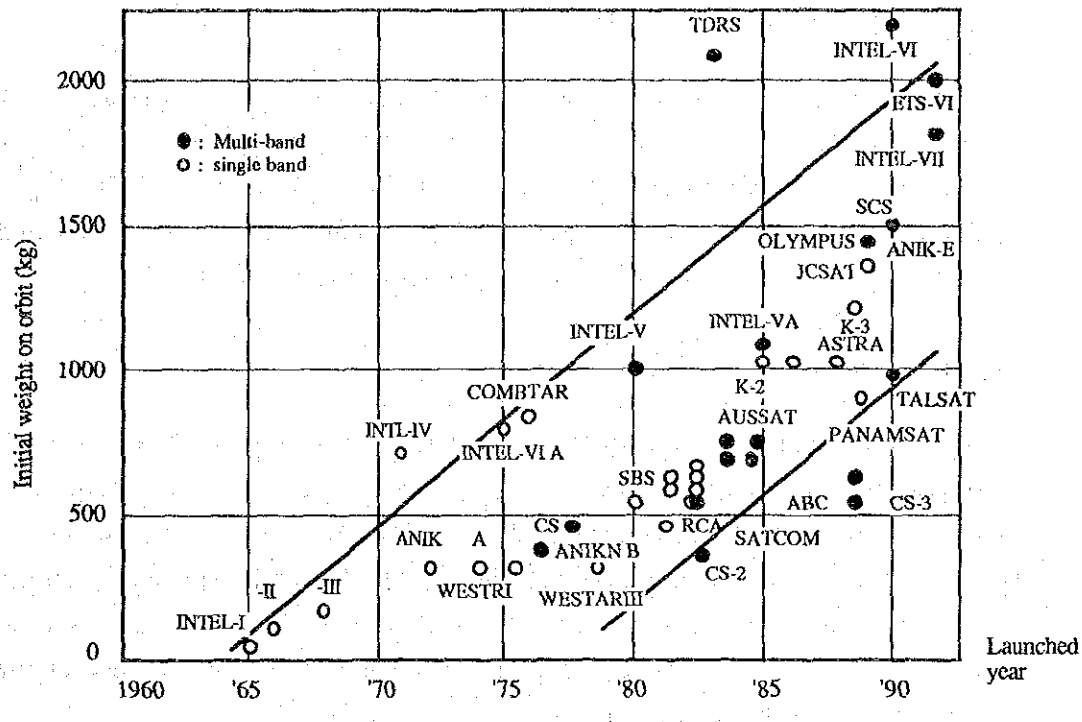


Figure 3.4.5-1 Trend of Satellite Size

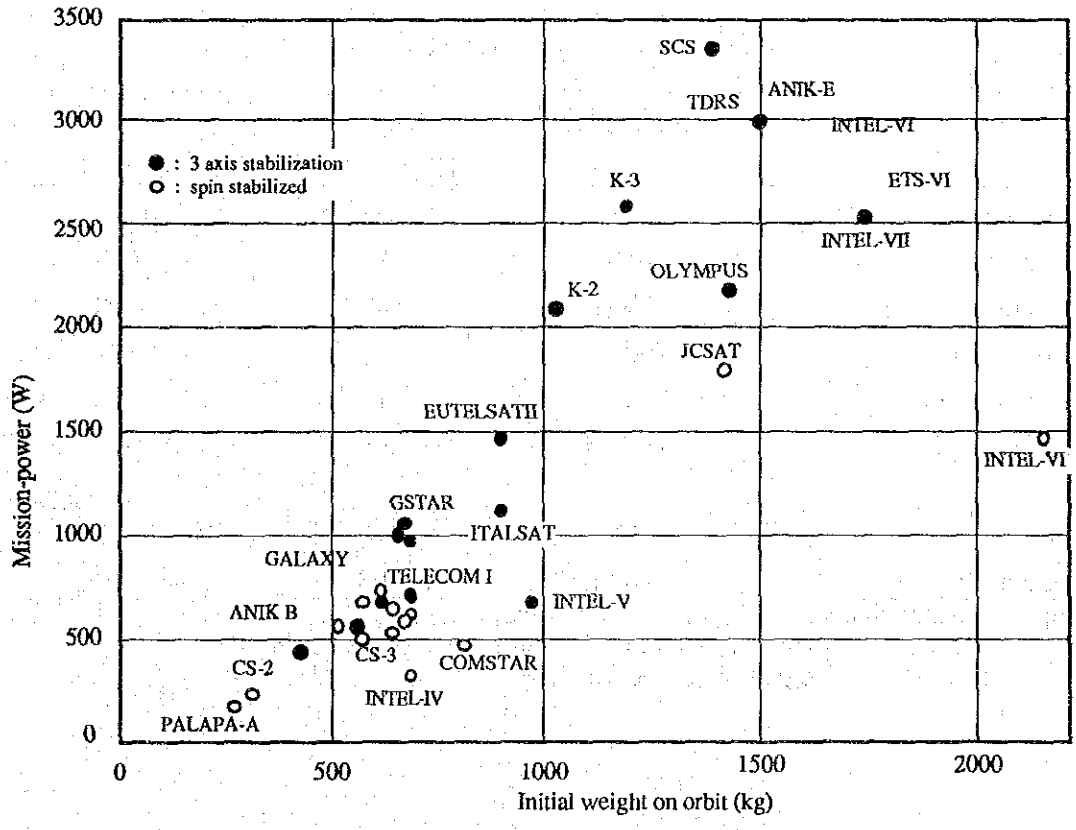


Figure 3.4.5-2 Trend of Mission-power

c) Installing multi frequency bands

The satellite communication systems used C-band (6/4 GHz bands) at first, and were expanded to use Ku-band (14/11, 14/12 GHz bands) and Ka-band (30/20 GHz bands) as the number of satellites increased. Technological development produced large scale satellites which were equipped with multi frequency band transponders. They brought down cost per transponder.

d) Multiple beams

A multiple beam satellite can increase transmission capacity, decrease earth station scales and costs, and realize construction of economical satellite communications systems. It also increases frequency utilization efficiency by being reused in several areas. Multiple beaming will be achieved by developing large antennas on large scale satellites. Figures 3.4.5-3 and 4 show the relationship between transmission capacity and the scale of satellite. Table 3.4.5 shows the multi-beams satellites which were launched and planned.

Table 3.4.5 Multi-beam Satellites

Country Name	North America	Italy	Japan	
	ACTS	ITALSAT	ETS-VI	
Launching	1992	1991.1	1993	
Weight (kg)	1410	800	2000	
Total Transmit. Power	1800	1564	4100	
Life time (years)	2 to 4	5	10	
Frequency band	Ka	Ka	Ka	S
Antenna Dia. (m)	2.2/3.3	2/2	2.5/3.5	3.5 common
Beams	18	6	4	5
Direction (degrees)	+-0.02	+-0.03	+-0.015	

Note: Antenna diameter Up-link/Down-link diameter
ACTS: Advanced Communication Technology Satellite
ETS-VI: Engineering Test Satellite -VI(6)

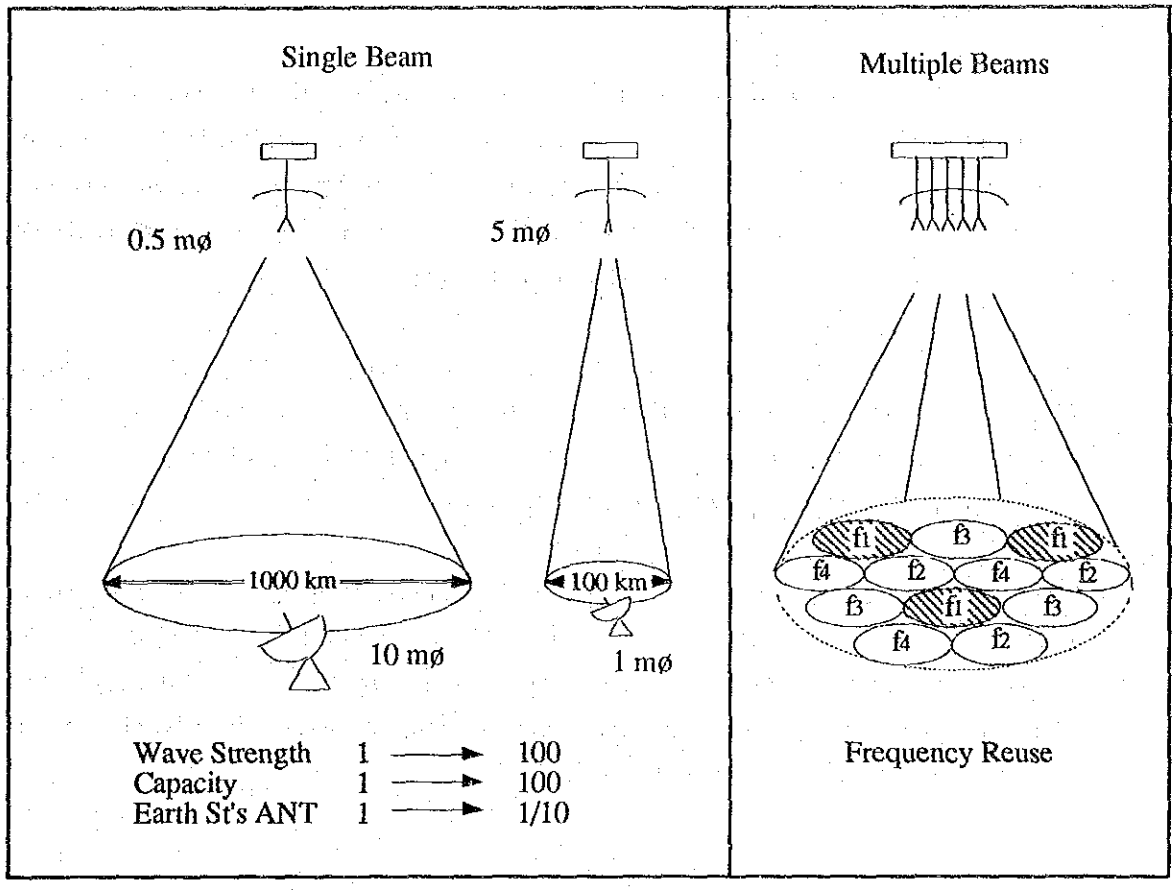


Figure 3.4.5-3 Concept of Multi-beems Satellite

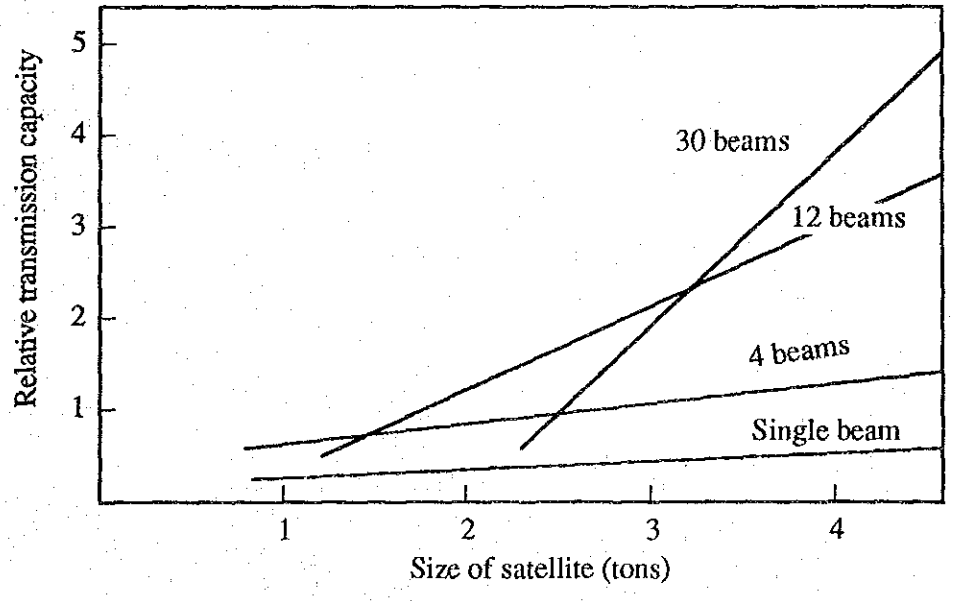


Figure 3.4.5-4 Increasing Transmission Capacity by Multi-beams

2) Mobile-Satellite Service Trend

The INMARSAT (International Maritime Satellite Organization) system covers the Atlantic, Pacific and Indian oceans. From suitably located geostationary satellites, using frequencies relatively unaffected by atmospheric conditions, line-of-site communications are possible to almost all commercial sea lanes. These satellites can provide 2-way communication services to some 5,000 commercial and private vessels.

INMARSAT is planning a new mobile satellite service system which is called the project 21st. The system will provide world-wide mobile communication services for business and private users like cellular systems. The service costs about 1,000 US$ for mobile equipment and 1 US$ for calling charge per minute.

The service will be offered by low earth-orbit (LEO) and/or high elliptical-orbit (HEO) satellites. Calls are connected to PSTNs via INMALSAT earth stations. Motorola also proposed world wide mobile satellite services with 77 low earth-orbit satellites. These plans will be implemented after frequencies being allocated in WARC (World Administrative Radio Conference) in 1992.

CHAPTER 4

PRESENT STATE OF TELECOMMUNICATIONS SERVICES IN BANGKOK METROPOLITAN AREA

CHAPTER 4 PRESENT STATE OF TELECOMMUNICATIONS SERVICES IN BANGKOK METROPOLITAN AREA

4.1 Ordinary Telecommunications Service

At present, the 5th and 6th projects of TOT are being carried out. As a result of both projects, the number of main telephones has approached to approximately one million three hundred and twenty five thousands (1,325,000) as of 1990 from approximately five hundred and twenty thousands (520,000) at the initial stage of the 5th project as shown in Table 4.1 and Figure 4.1.

Table 4.1 Number of Main Telephones

Unit:Thousand lines

Year	1984	1986	1987	1988	1989	1990
Number of main telephones	520	799	902	1,006	1,158	1,325
Metropolitan area	362	548	615	686	792	901
Provincial area	158	251	287	320	366	424
Telephone density (Main telephones/100 persons)	1.03	1.51	1.67	1.83	2.07	2.35
Metropolitan area	5.43	7.73	8.74	9.55	10.87	12.86
Provincial area	0.36	0.55	0.69	0.76	0.85	0.92

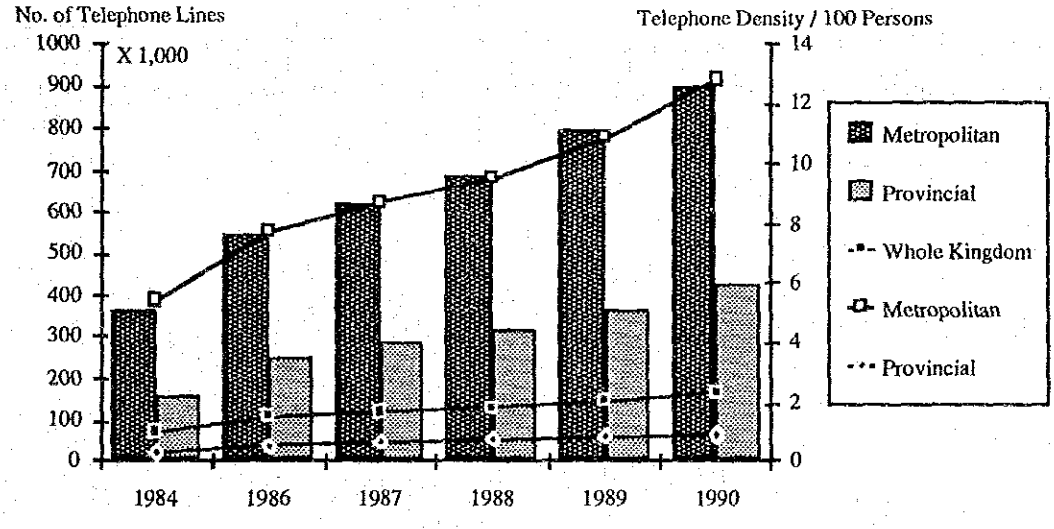


Figure 4.1 Number of Main Telephones

4.2 Other services

Two state enterprises, TOT and Communications Authority of Thailand (hereinafter refer to as "CAT"), had dominated the telecommunications market in Thailand. Recently, however, several private companies have entered into the market and are offering telecommunications services. These private companies, known as the new common carriers, were allowed to do business by either TOT or CAT.

Though some of these new common carriers provide their telecommunications services by using their own facilities, most of them have to use the TOT's facilities because they do not have facilities which serve their customers.

For TOT, this means that TOT's facilities should be well maintained since TOT has accepted the new common carriers to be connected to the TOT's networks.

In addition,TOT's network management and operation should be enhanced to a greater degree due to the entry of these new common carriers. TOT should manage the networks effectively to avoid any network congestion.

4.2.1 Structure and Provision of Telecommunications Services

The present telecommunications services which are provided by TOT and CAT are shown in Table 4.2.1-1

In addition, a variety of services and projects offered by the new common carriers are being provided or planned on concession bases. Table 4.2.1-2 lists an out line of these services and projects.

Table 4.2.1-1 Structure and Provision of Telecommunications Services

Telecommunication Services			Domestic		International	
			TOT	CAT	TOT	CAT
Telephone (Voice) Communication	Ordinary Telephone	Call Service	S		S	S
		Network Service	S			
		Terminal Connection e.g. Facsimile Terminal, Data Terminal etc.	S	S		S
	Public Telephone	Coin (Local)	S			
		Coin (STD)	S			
		Card Phone	S			
	Radio & Mobile Telephone	Cellular Mobile Telephone	S	S		
		Paging Station	S	S		
		Train Telephone	S			
		Airplane Telephone	P	P		
		Maritime Telephone		S		
Leased Circuit	Telex Access Line as Local Cable		S	S		
	Teletype & Telegraph		S	S		S
	Broadcast Program Transmission		S	S		S
	Data Transmission		S	S		S
	Telegram			S		S
Recorded Communication	Telex			S		S
	Teletex (Super Telex)			S		S
	Photo-Telegraph			S		S
	Bureau Facsimile			S		S
Video Communication	Videotex		P			
	Video Conference		P			

Note: P: Planning S: In service
STD: Subscriber Toll Dialling(Long Distance Call)

Table 4.2.1-2 Present State of Telecommunication Services and Projects 1/4

Category	Project or Service	Carrier or Provider (Concessioner)	Service Coverage Area or Project Scale	Usage	Under Plan	On Going	In Service
Domestic telecommunication services	Optical fiber cable for long distance	TOT and SRT (Comlink)	Along railway, 3,000km length 1.BKK~Phitsanulok~Chaing Mai 2.BKK~Udon Thani 3.Bkk~Ubon Ratchatani 4.BKK~Yala~Narathiwat 5.BKK~Rayong~Chantaburi	TOT: Long distance(40,000 lines), Train telephone SRT: Signalling system		●	
	Submarine cable	TOT (STC)	Rayong~Naratiwat 1,200km length			●	
International telecommunication services	Access line for gate way switch	TOT & CAT	ITSC-1 Bang Rak(CAT)~ All TCs(TOT) ITSC-2 Nonthaburi(CAT)~ All TCs(TOT) ITSC-3 Eastern Sea Bord(CAT)~ Area 038,039	Access line to ITSC(CAT)		 ● ●	●
	ASEAN optical fiber cable project (submarine cable)	CAT	Phetchaburi~Kuantan(Malaysia) Phetchaburi~BKK BKK~Nonthaburi Phetchaburi~Laem Chabang Laem Chabang~	N.A.	●		

Table 4.2.1-2 Present State of Telecommunication Services and Projects 2/4

Category	Project or Service	Carrier or Provider (Concessioner)	Service Coverage Area or Project Scale	Usage	Under Plan	On Going	In Service
Mobile Communication	Cellular mobile telephone	TOT	Area (whole country) No. of subscribers (42,712 as of Sep.1991)	Nordic Mobile Telephone System 470 MHz			● 1986.7
		TOT (Chinawatra)	Areas(Whole country) No. of subscribers (36,486 as of Sep. 1991)	Nordic Mobile Telephone System 900 MHz			● 1990. 10
		CAT	Areas(BKK and big town) No. of subscribers (44,343 as of Sep. 1991)	Advanced Mobile Telephone System 800 MHz			● 1987.2
		CAT (new concession)	----------	----------	●		
	Paging (Phonelink)	TOT (Digital Paging Co)	Whole country No. of terminals (74,868 as of Sep. 1991)	----------			● 1990.1
	Paging (Pagephone)	TOT (Hudgison Telecommunication Co.)	Whole country No. of terminals (14,004 as of Sep. 1991)	----------			● 1990.12
	CT-2 (Fonepoint)	TOT (Chinawatra)	BKK metropolitan telecommunication area No. of Users (100 as of Sep.1991) (2,907 as of Jul. 1992)	----------			● 1991.8
	Paging (Paclink)	CAT (Pacific Telesis Co.) (Matrix Co.)	No of subscribers (about 80,000 as of Sep. 1991)				● 1987
	Paging	CAT	No. of subscribers (about 10,000 as of Sep. 1991)				●

Table 4.2.1-2 Present State of Telecommunication Service and Project 3/4

Category	Project or Service	Carrier or Provider (Concessioner)	Service Coverage Area or Project Scale	Usage	Under Plan	On Going	In Service
Mobile Communication	Maritime Telephone	CAT	Siam Gulf				●
Data communication	Leased circuit	TOT	Whole country No. of lines(17,620 as of Sep. 1991) BKK=10,619 Prov.= 7,001	Hot line Telex Data communication			●
	DDN Digital Data Network	TOT	Whole country 2,400 b/s to 64 kb/s	1.Point to point service 2.Multipoint services 3.Netplex services 4.Analog modem access services 5.Customer test system			●
	DATANET	TOT (Chinawatra)	Bangkok Metropolitan Telecommunication Area Up to 19.2 kb/s No. of Subscribers(approximately 200) No. of ports(approximately 1,000 as of Aug. 1991))	1.Remote access to database 2.Remote access to computer 3.On line ticket reservation system 4.Point of sale 5.Remote access to ThaiPak 6.Remote access to any X.25 host			● 1990.3
	Electronics data Interchange (EDI)	CAT	----------	Data-base service	●		
	TELEBOX	CAT	Message transfer	Through TaiPak			●
	DPZ	Government	Physical zone: BKK	----------	●		
	Teleport	TOT & CAT	Eastern sea boad	----------		●	
	High speed	CAT	64 kb/s~2 Mb/s No. of lines (1 as of Jul. 1991)	Digital data communication service			●

Table 4.2.1-2 Present State of Telecommunication Services and Projects 4/4

Category	Project or Service	Carrier or Provider (Concessioner)	Service Coverage Area or Project Scale	Usage	Under Plan	On Going	In Service
Satellite communication		TOT (Acumen Co.)	10 earth stations in Thailand	PALAPA Domestic communication			●
		MOC (Shinawatra)	Whole country	Domestic communication		● 1993	
		CAT	Earth station: Sri Racha	International communication			●
Video tex		Line Technology (France)	Whole country	Business information based services	●		
Public telephone		TOT (Advance Information Service)	Card telephone No. of telephones(129) Aug 1991				●

4.2.2 Mobile Telecommunications Services

The mobile telecommunications services are divided roughly into two categories, namely, paging service and cellular mobile telephone service. The former is for receiving a calling signal via a ringing or a message on the display of a terminal set. The later is has the same function as the ordinary telephone.

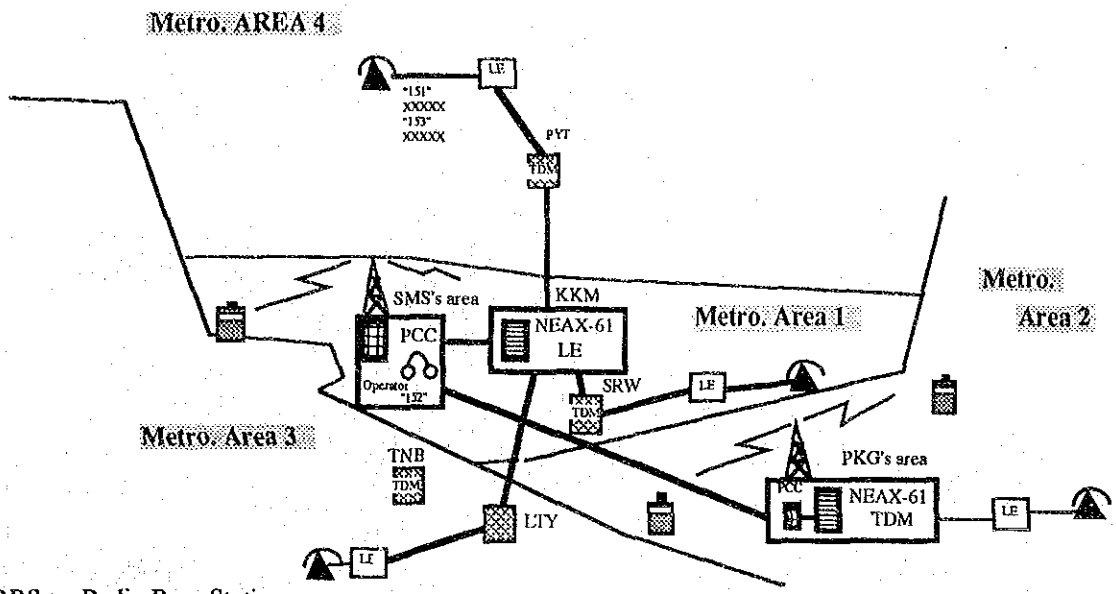
In Thailand, both services are provided by not only TOT and CAT but also the new common carriers on the concession basis.

1) Paging Service offered by TOT

The development of the paging service offered by TOT is shown in Table 4.2.2-1. Figure 4.2.2-1, Figure 4.2.2-2 and Figure 4.2.2-3 show the network concept of the paging services and Fonepoint service.

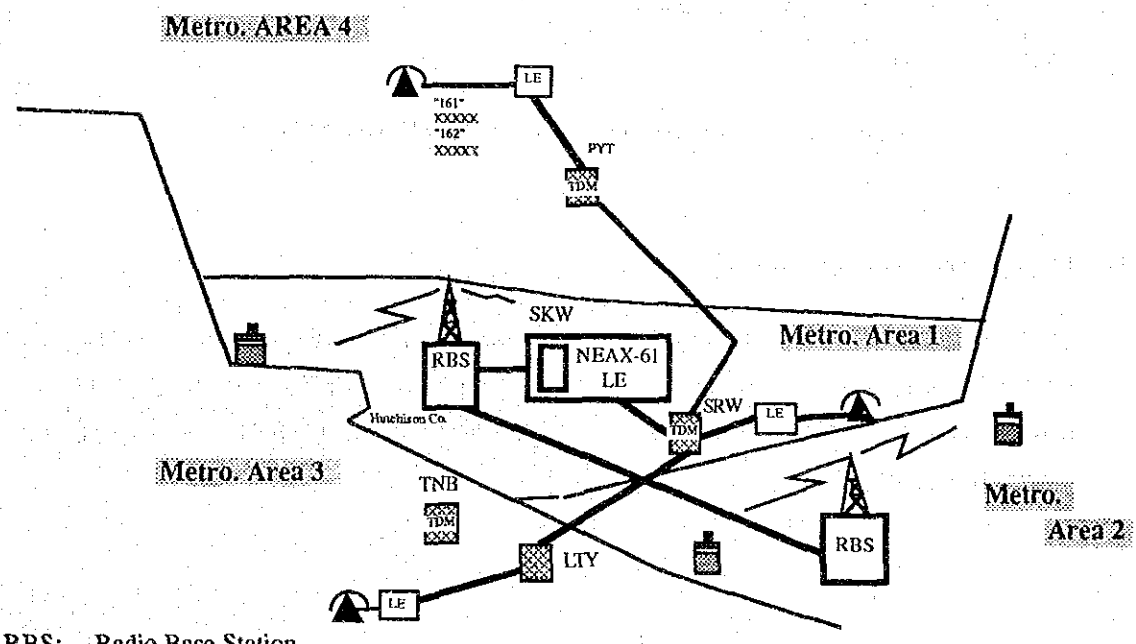
Table 4.2.2-1 Development of Paging Services Offered by TOT

	1990			1991							
	Aug.	Dec.	Jan.	Feb.	Mar.	Apl.	May	Jun.	Jul.	Aug.	Sep.
Paging Phone	-	-	-	2,027	3,430	4,146	5,316	7,866	n.a.	n.a.	14,004
PhoneLink	16,172	38,442	42,287	45,299	48,889	51,301	57,612	61,880	66,194	n.a.	74,863
Fonepoint	-	-	-	-	-	-	-	-	-	-	200



RBS: Radio Base Station
PCC: Paging Control Center

Figure 4.2.2-1 Network Concept of Paging Service(15X) Offered by TOT



RBS: Radio Base Station

Figure 4.2.2-2 Network Concept of Paging Service(16X) Offered by TOT

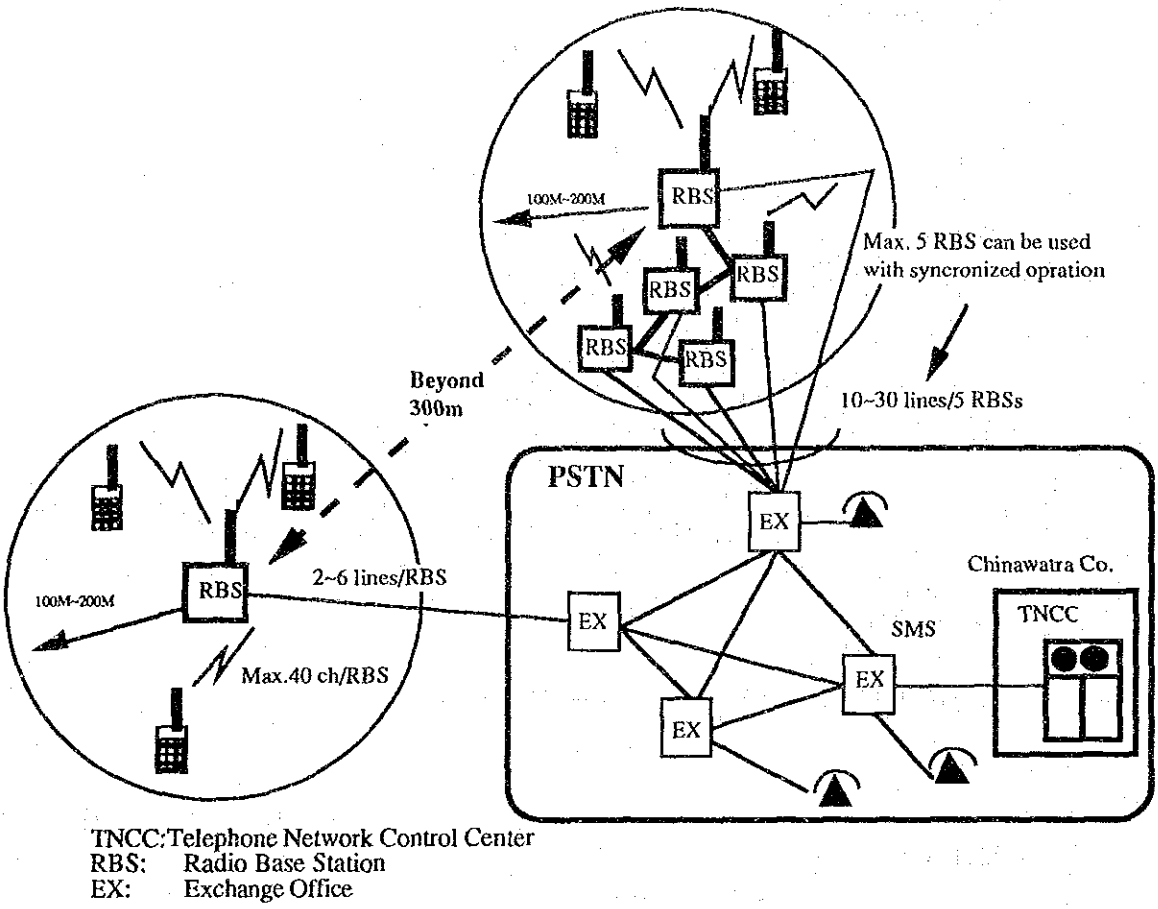


Figure 4.2.2-3 Network Concept of Fonepoint Offered by TOT

2) Paging Service offered by CAT

CAT has been providing the paging service approximately for the past 10 years. The number of subscribers is approximately ninety thousands (90,000) including the service offered by CAT itself. The network concept of the paging service offered by CAT is shown in Figure 4.2.2-4.

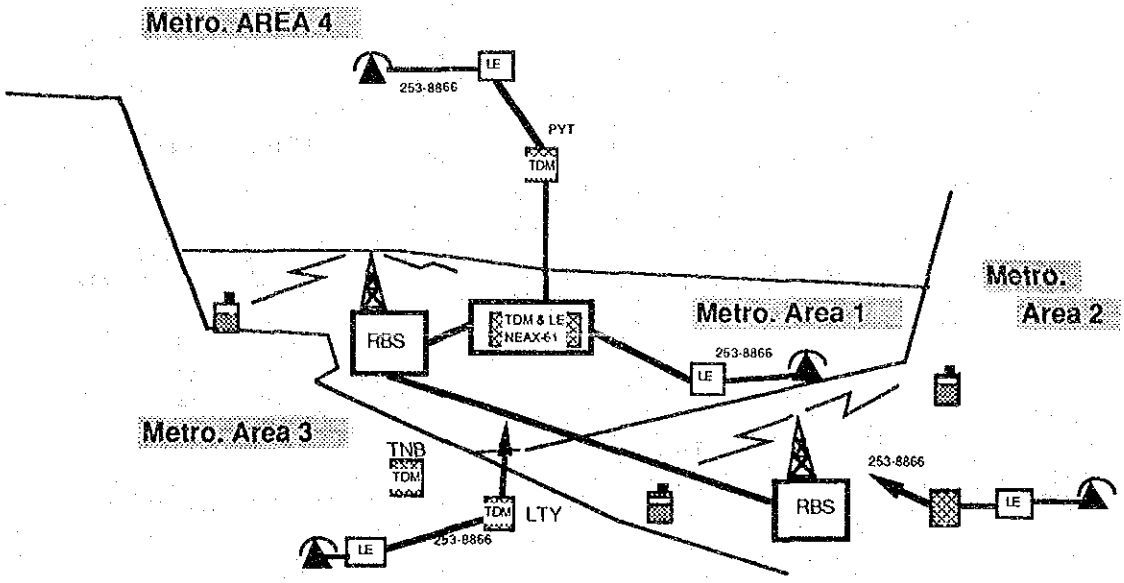


Figure 4.2.2-4 Network Concept for Paging Service Offered by CAT

3) Cellular Mobile Telephone Service offered by TOT

TOT is providing the cellular mobile telephone service by using two Nordic Mobile Telephone Systems (NMT) adopting two kinds of frequencies. One is 470 MHz and the other is 900 MHz.

Table 4.2.2-2 shows the development of the mobile telephone service offered by TOT and Figure 4.2.2-5 shows the network concept.

Table 4.2.2-2 Development of Cellular Mobile Telephone Services in Thailand

		1986	1987	1988	1989	1990	1991
TOT	470MHz	822	4,413	10,612	20,936	31,981	42,712
	900MHz	-	-	-	-	-	36,486
CAT	800MHz		1,166	6,972	14,171	31,242	44,343
Total		822	5,579	17,584	35,107	63,223	123,541

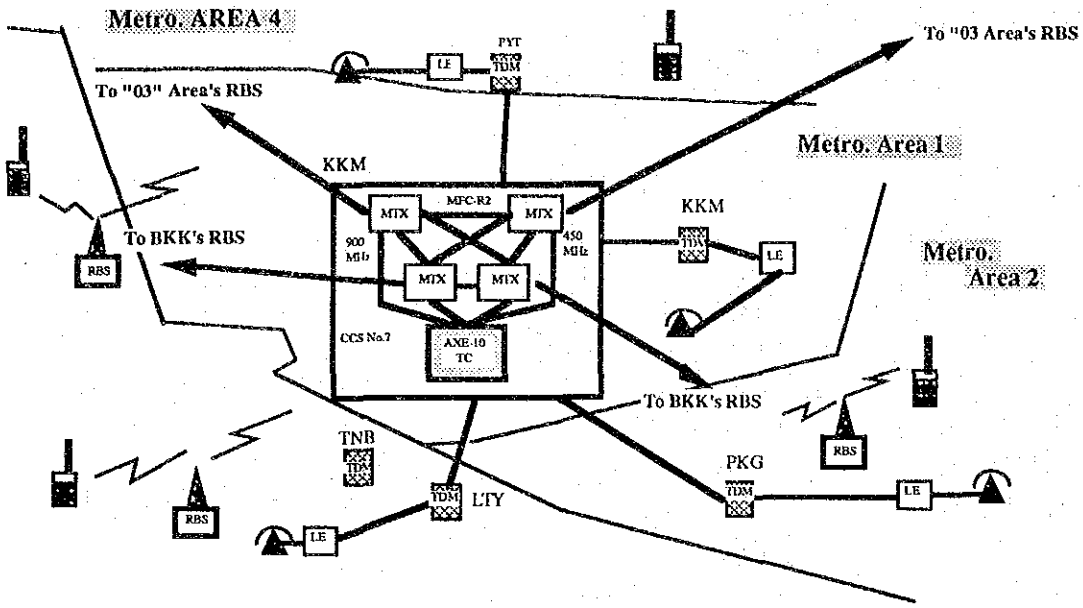


Figure 4.2.2-5 Network Concept of Cellular Mobile Telephone offered by TOT

4) Cellular Mobile Telephone Service offered by CAT

CAT is providing the cellular mobile telephone service by using an Advanced Mobile Phone System (AMPS) adopting 800 MHz. Table 4.2.2-2 also shows the development of the cellular mobile telephone service offered by CAT.

The network concept of the cellular mobile telephone service offered by CAT is shown in Figure 4.2.2-6.

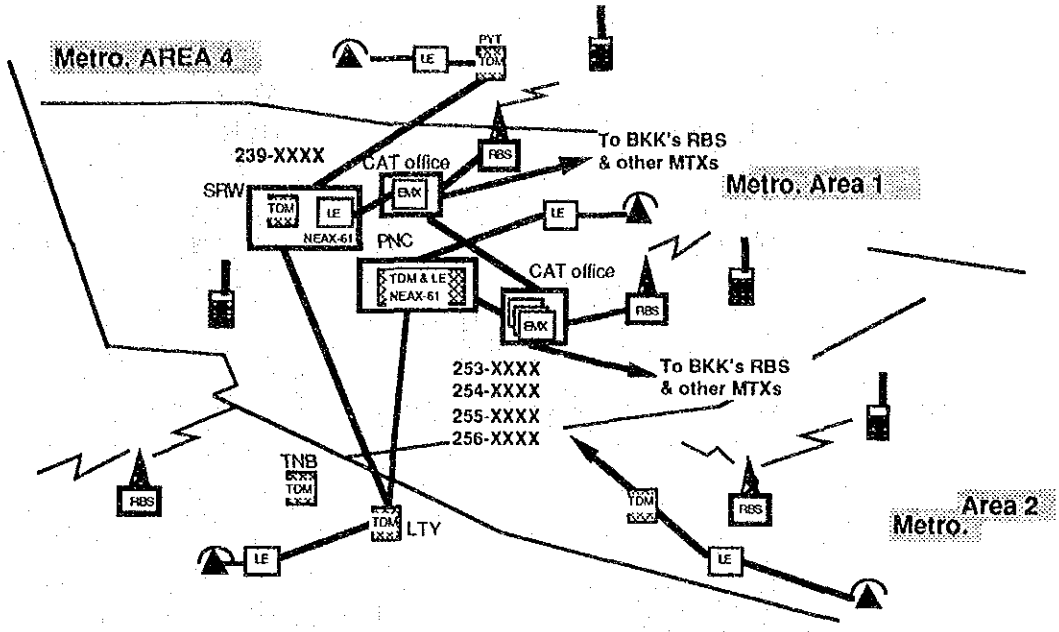


Figure 4.2.2-6 Network Concept of Cellular Mobile Telephone Service offered by CAT

4.2.3 Leased Circuit Services

The present state of the leased circuit services in the metropolitan telecommunication area is shown in Table 4.2.3, Figure 4.2.3-1 and Figure 4.2.3-2.

Table 4.2.3 Present State of Leased Circuit Services

Maintenance Area	No. of lines	Category	No. of lines
Metro. 1	8,278	Computer	4,903
Metro. 2	622	Teletex	422
Metro. 3	671	Telex	3,799
Metro. 4	1,104	Hot Line	725
Total	10,675	Broadcast	771
		Other(Telegram)	55
		Total	10675

Source: TOT Maintenence Report Jun. 1991

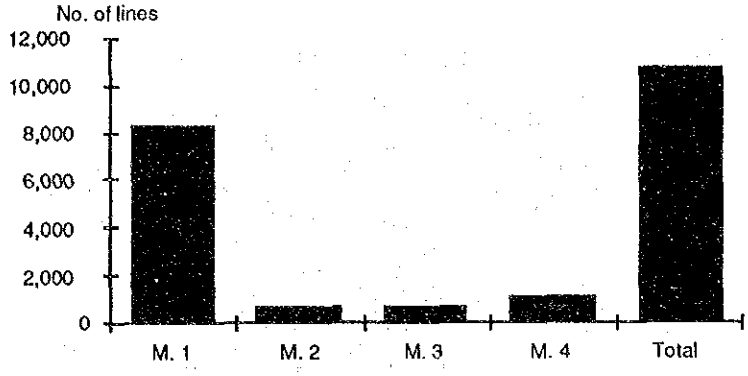


Figure 4.2.3-1 Present State of Leased Circuit Services in the Metropolitan Area

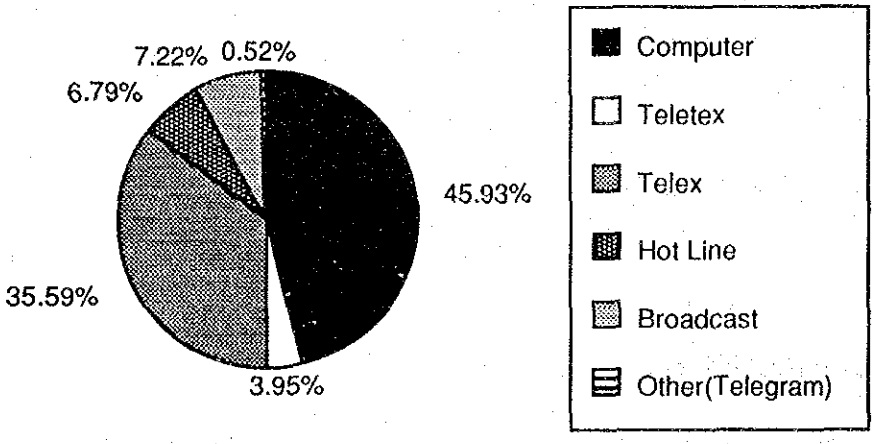


Figure 4.2.3-2 Number of Leased Circuits Categorized by Use

4.2.4 Data Transmission Services

1) DATANET

DATANET is a data transmission service with a speed of 19.2 kb/s by using the existing subscriber lines. This service is a packet switching service. Once the data is sent to a telephone office, the data is transferred to the destination through a dedicated network for DATANET. This service can cover 31 local exchange areas in the BMA at present. However, in near future, the covered areas will be expanded to the whole Kingdom. The number of subscribers is approximately 200 and that of ports for this services is approximately 1,000 at present. Figure 5.2.3-1 shows the network configuration of DATANET.

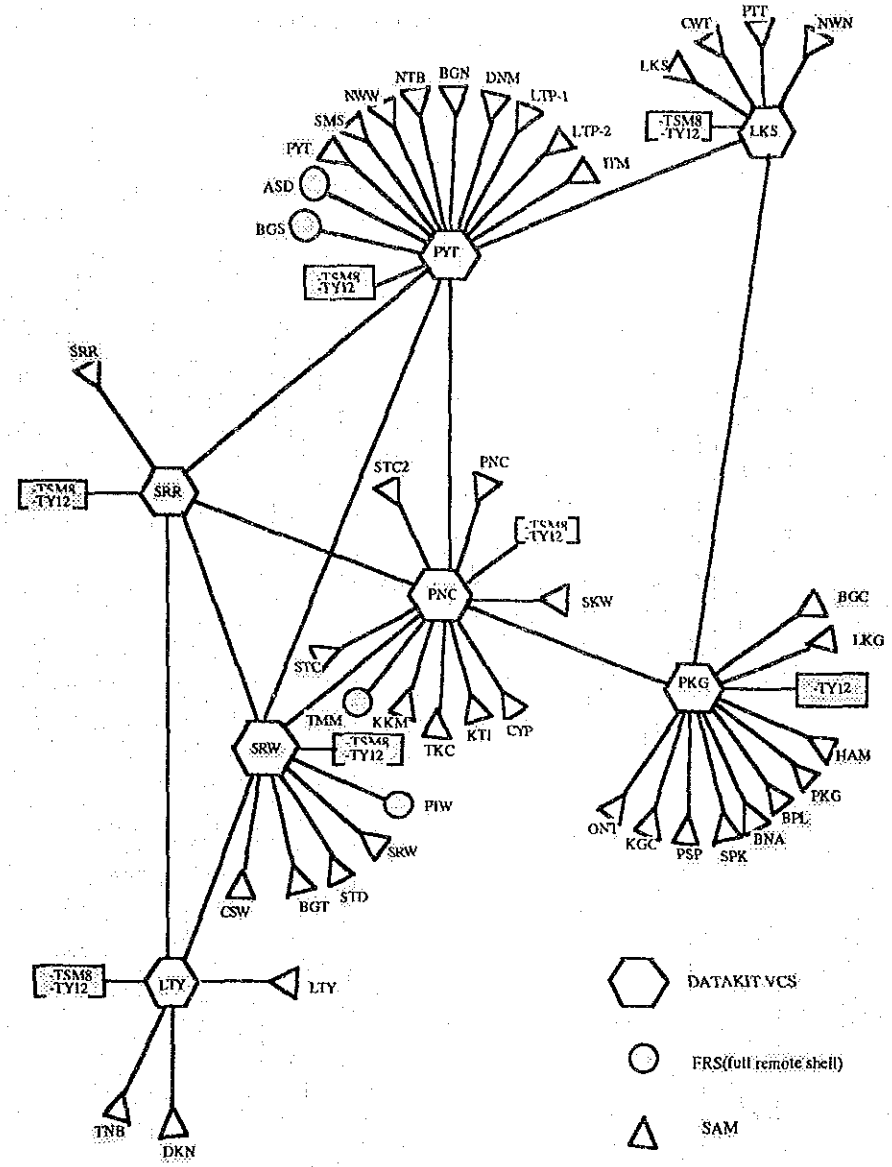


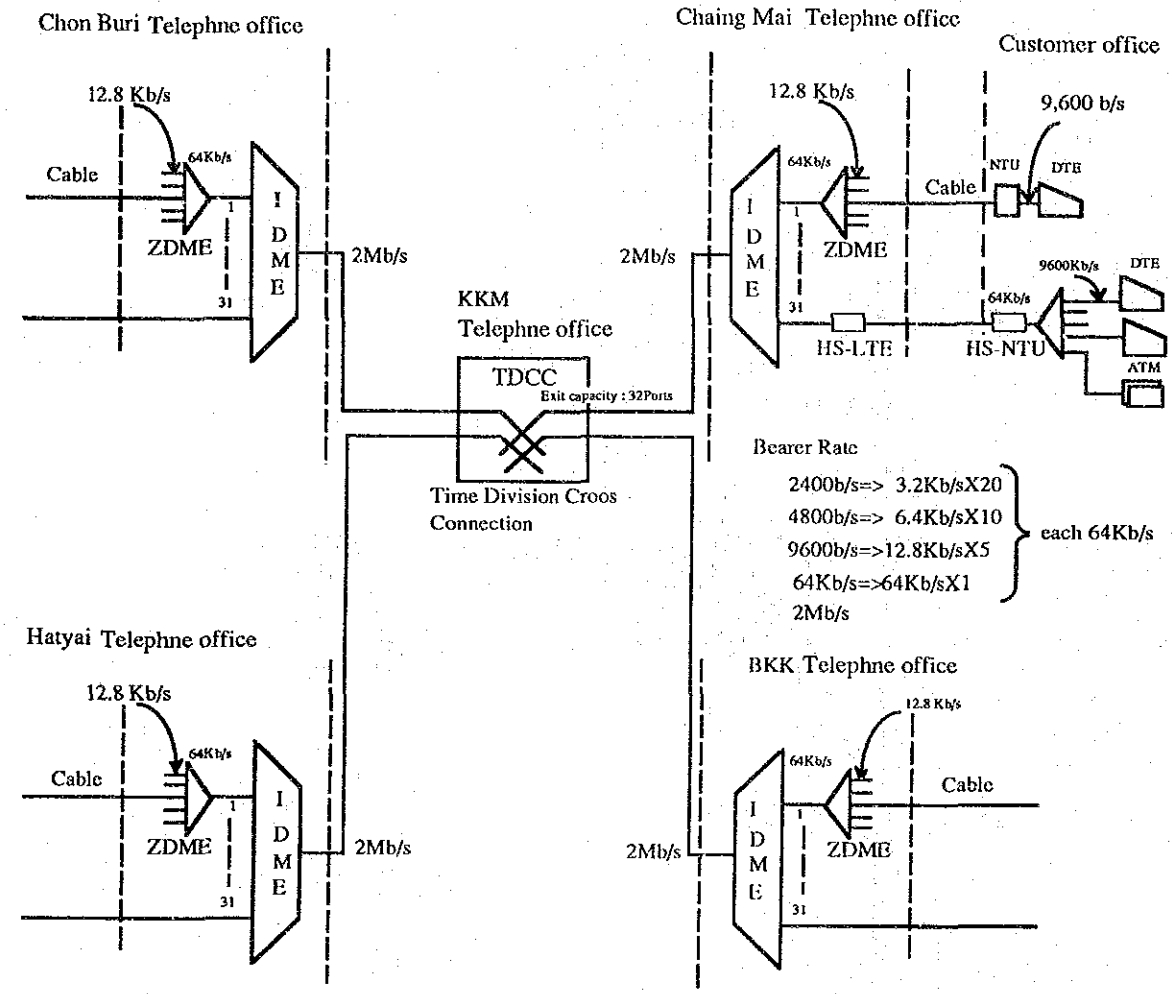
Figure 4.2.4-1 Network Configuration of DATANET

2) Digital Data Network (DDN) Service

This service provides a data transfer service at various transmission speeds from 2,400 bit/s to 64 kb/s.

At present, one Time Division Cross Connection (TDCC) which is installed at the Krung Kasem telephone exchange office is operated for controlling all the existing circuits. In addition to this, TOT has a plan to install 7 more TDCCs; 3 tertiary centers in the BMA and 4 tertiary centers in the provincial areas.

Figure 4.2.4-2 shows the network configuration of DDN. The number of facilities is listed in Table 4.2.4.



Note HS-LTE: High Speed Line Terminating Equipment
HS-NTU: High Speed Network Terminating Unit

Figure 4.2.4-1 Network configuration of DDN

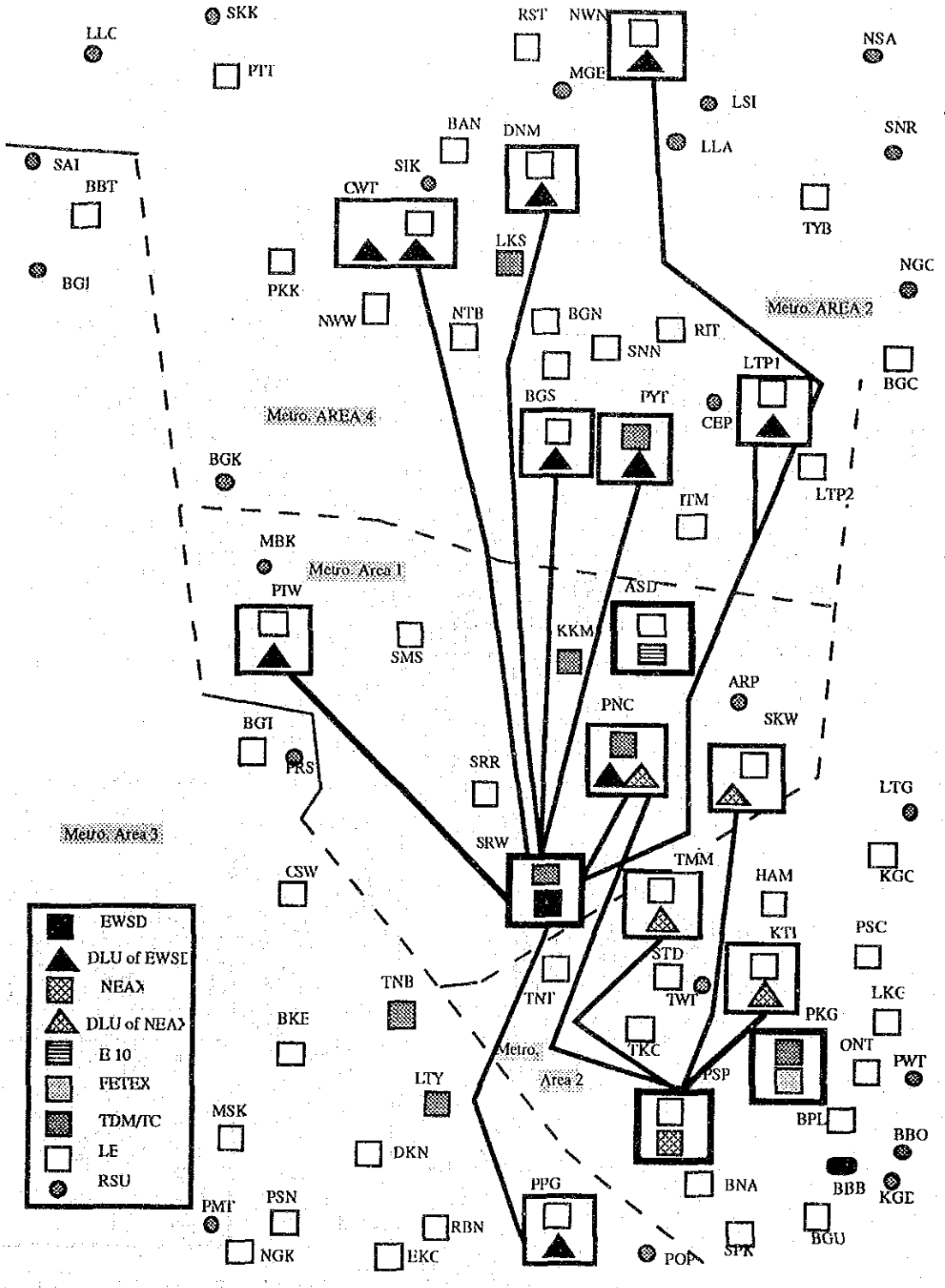
Table 4 .2.4 Present State of DDN

Exchange Name	No. of Available Lines		No. of Connected Lines	
	9,600 bps	64 Kbps	9600 bps	64 Kbps
Ploenchit	35	20	35	20
Sukhumvit	10	-	6	-
Chaiyapruk	10	-	2	-
Surawong	30	10	21	3
Phahonyothin	20	10	4	3
Krungkasem	55	6	55	1
Samsen	5	-	1	-
Ratburana	5	-	1	-
Thanon Tok	5	-	1	-
Bang Chan	5	1	1	1
Trok Chan	5	-	1	-
Samranrat	10	10	7	-
Lat Ya	5	10	1	4
Phasi Charoen	5	-	2	-
Klong Chan	10	5	-	1
Phrakanong	10	5	1	2
Klong Toe	15	10	12	1
Lat Prao 1	5	5	1	2
Thung Mahamek	5	-	-	-
Don Moeng	10	5	-	5
Ngam Wongwan	10	1	10	2
Thonburi	5	5	2	1
Hua Mak	5	5	1	1
TOT	-	31	-	11
Lak Si	5	5	-	3
Pak Kret	15	5	15	5
Bang Sue	5	-	1	
Chang Wattana	30	1	26	1
Asok Dindaeng	5	-	1	-
Pathumwan	5	-	1	-
Hatyai	14	5	6	1
Prachin Buri	10	5	6	-
Puket	9	-	2	-
Nakorn Sawan	10	-	2	-
Chaing Mai 2	10	-	2	-
Chaing Mai 4	10	-	2	-
Pitsanuloke	-	2	-	1
Nakorn Ratchasima	5	-	5	-
Ubon Ratchatani	5	-	5	-
Chon Buri	5	-	-	-
Cha Choengsoa	10	-	-	-
TOTAL	433	162	239	69

4.2.5 ISDN Services

In order to begin ISDN services on February 24, 1992, which is the 38th anniversary of the existence of TOT, TOT has established a new division which undertakes ISDN service project and all divisions including new one are examining the matters to be resolved such as stadardization of interface between different switch makers for providing ISDN services.

The network configuration of the ISDN pilot plan is shown in Figure 4.2.5-1 and 4.2.5-2. According to the plan, most of main cities in Thailand will be covered.



EWSD: SIMENS's switching system
NEAX: NEC's
E10: ALCATEL's
FETEX: FUJITSU's
DLU: Digital line unit

Figure 4.2.5-1 Network Configuration of ISDN Service in the BMA

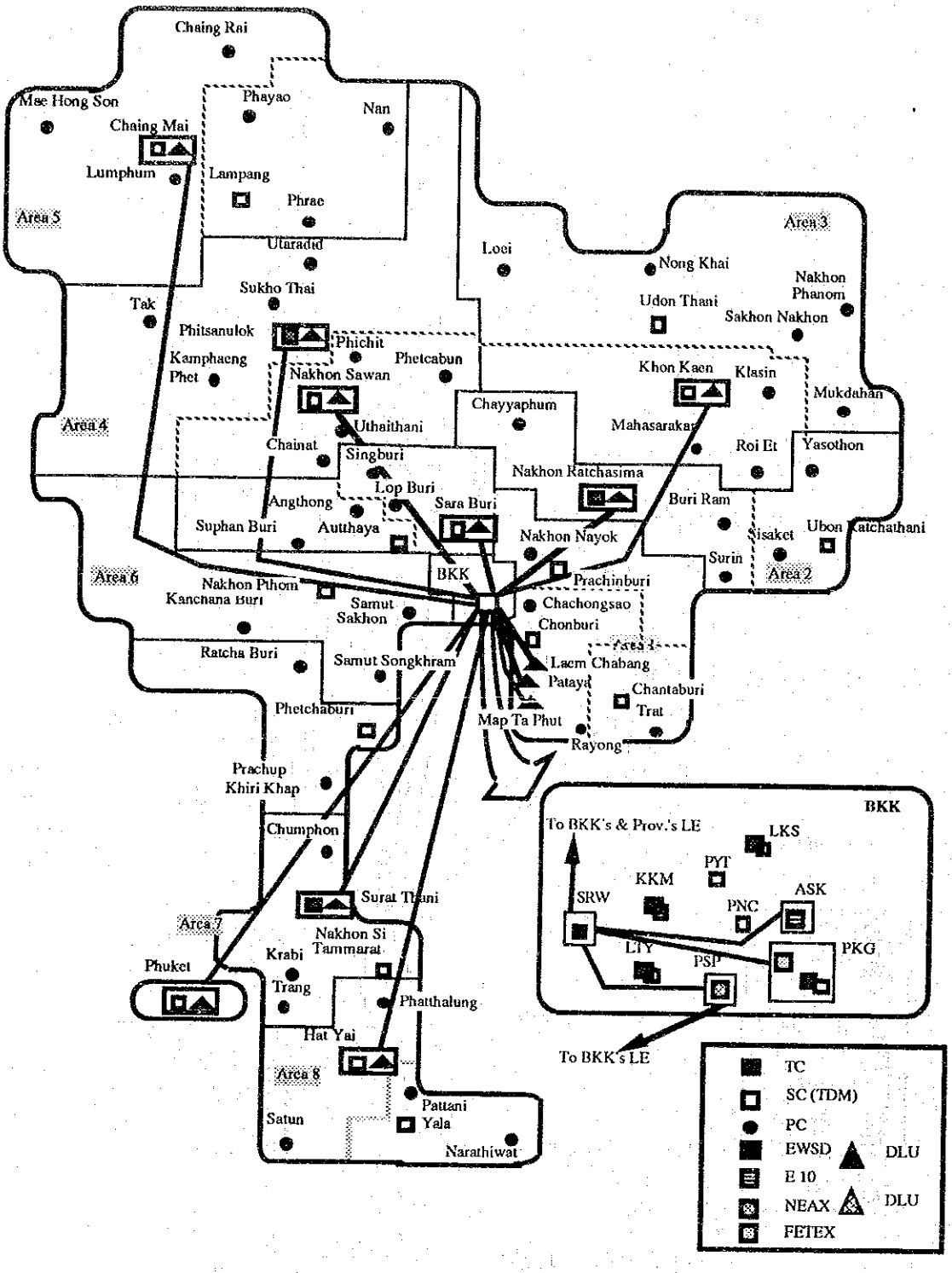


Figure 4.2.5-2 Network Configuration of Nationwide ISDN Services

CHAPTER 5

PRESENT STATE OF TELECOMMUNICATIONS NETWORKS

CHAPTER 5 PRESENT STATE OF TELECOMMUNICATIONS NETWORKS

5.1 Network Configuration

5.1.1 Domestic Network Configuration

The telephone network of the Kingdom covers the following five (5) telephone areas.

	Area Code
Metropolitan area	2
Central area	3x
North-eastern area	4x
Northern area	5x
Southern area	7x

The telephone areas mentioned above are called Tertiary Areas. The tertiary areas except the Metropolitan area are divided into Secondary Areas. The secondary areas are further subdivided into Primary Areas. There are twenty (20) Secondary Areas and seventy-four (74) Primary Areas in the whole Kingdom.

The telephone network is established with a three level hierarchy in the Metropolitan area and a four level hierarchy in other provincial areas as shown in Figure 5.1.1-1.

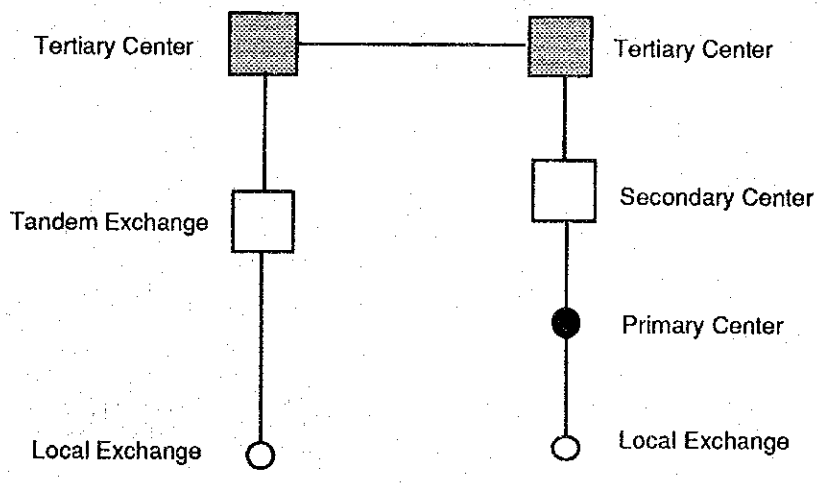


Figure 5.1.1-1 Network Hierarchy

As of the base year (1992), there are 7 Tertiary Centers (TC) (4TCs are in Bangkok and 3 TCs are in the provincial areas). Each TC is connected to the International Transit Switching Center (ITSC). The numbering areas in each TC are as follows.

Lak Si (LKS)	02 numbering area
Phra Khanong (PKG)	02 numbering area
Lat Ya (LTY)	02 numbering area
Krung Kasem (KKM)	03-x numbering area (Central area)
Nakhon Ratchasima (NMA)	04-x numbering area (North-eastern area)
Phisanulok (PNK)	05-x numbering areas (Northern area)
Sura Thani (SNI)	07-x numbering areas (Southern area)

The far to near rotation method is adopted as the traffic routing principle. Routes between 2 exchanges are regarded as high usage routes if the traffic between them is 15-20 erlangs or more. It is increased in steps of 30 channels (1 DTI). Furthermore, from a secondary exchange, a direct route is established to every tertiary exchange.

Traffic routing for long distance calls is shown in Figure 5.1.1-2. Switching areas in the Study Area are shown in Table 5.1.1.

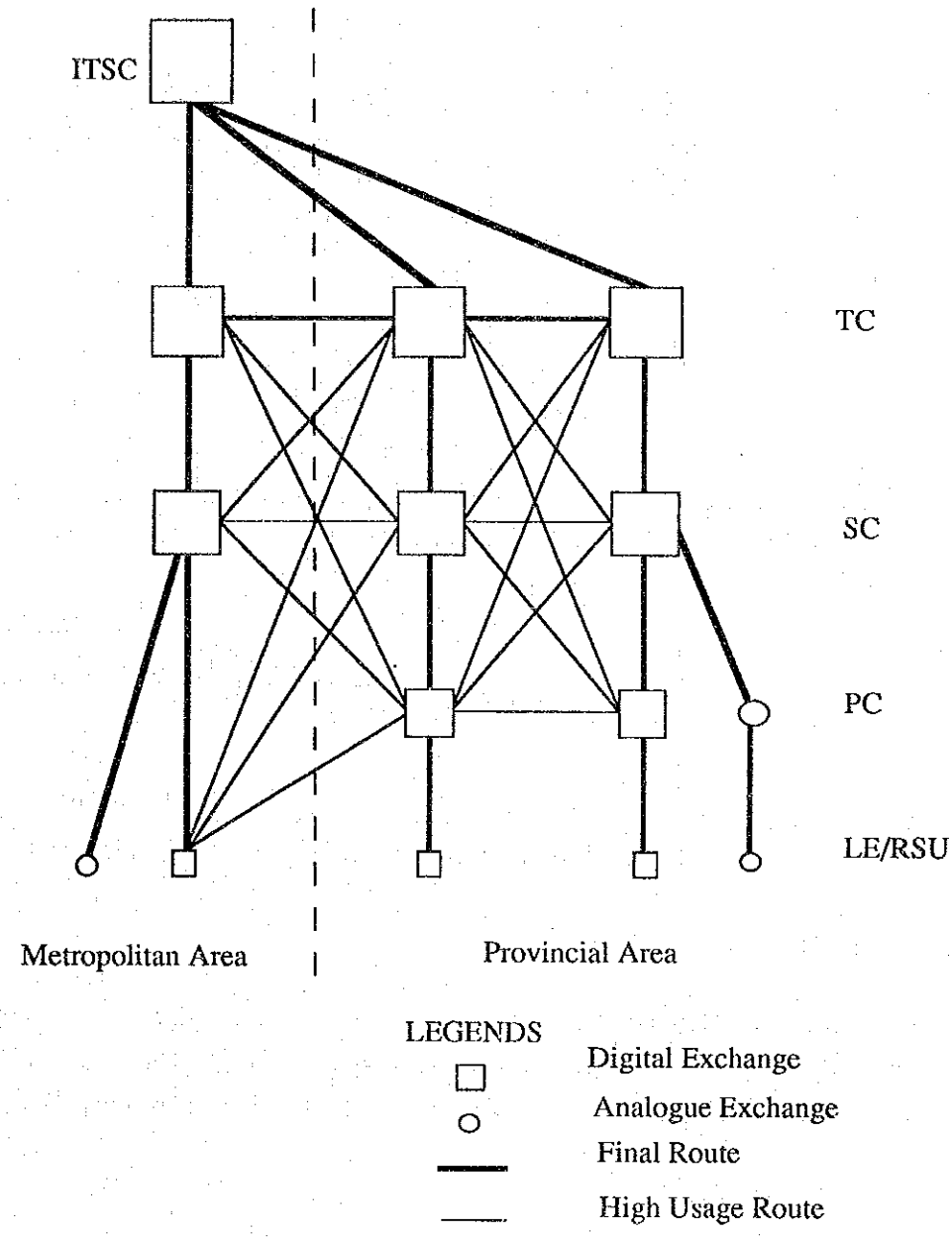


Figure 5.1.1-2 Traffic Routing for Long Distance Traffic

Table 5.1.1 Switching Area in the Study Area

Tertiary Area Code	Tertiary Center	Secondary Area Code	Secondary Center (Tandem)	Primary Center
02	Lak Si Phra Khanong Lat Ya	02	Krung Kasem (T1) Phahonyothin (T2) Ploenchit (T3) Lak Si (T4) Thon Buri (T5) Phra Khanong (T6) Surawong (T7) Lat Ya (T8)	
03	Krung Kasem	034	Nakhon Pathom	Nakhon Pathom Samut Sakhon (Samut Songkram) (Kanchanaburi)
		035	Ayuthaya	Ayuthaya (Ang Thong) (Suphan Buri)

( ) shows primary center which is not included in the study area.

5.1.2 Metropolitan Network Configuration

The network in the BMA is applied with a dispersed tandem system. There are 4 XB tandem exchanges and 6 SPC tandem exchanges for 8 tandem areas.(T1-T8). The dispersed tandem exchange system is shown in Figure 5.1.2-1. The tandem exchange names are shown in Table 5.1.2.