Investment Estimation of Telecommunication Industry in Japan: A Study in the Economics of Information Society

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This work reports an estimate of demand for telecommunication services and an estimate of the investment cost of constructing telecommunication infrastructure in Japan for the period of 1996–2025. Economic models are formulated to describe main activities of the Japanese telecommunication industry including mobile communication, the Internet, Public Switched Telephone Network PSTN and Broadband Integrated Services Digital Network B-ISDN. Under a number of assumptions on macro economic and social indices, we make a forecast of the number of subscribers to telecommunication services, the amount of investment to satisfy the demand, the operating costs, the operating incomes and loses, and the cash-flow of the operator. Comparing some scenarios, we estimate the amount of public finance to promote the construction of the information infrastructure.

KEYWORDS: Telecommunication industry, Information society, ISDN, Telecommunication infrastructure, Internet

1 Introduction

This work reports an estimate of demand for telecommunication services and an estimate of the investment cost of constructing telecommunication infrastructure in Japan for the period of 1996–2025. Economic models are formulated to describe main activities of the Japanese telecommunication industry including mobile communication, the Internet, Public Switched Telephone Network PSTN and Broadband Integrated Services Digital Network B-ISDN.^{*1)} Under a number of assumptions on macro economic and social indices, we make a forecast of the number of subscribers to telecommunication services, the amount of investment to satisfy the demand, the operating costs, the operating incomes and loses, and the cash-flow of the operator. Comparing some scenarios, we estimate the amount of public finance to promote the construction of the information infrastructure.

Facing the 21st century, where high economic growth ceases to exist, each country is confronted with the common problem of sustainable economic growth and changing the economic restructuring. Recently, the information communications industry has come into the spotlight because of the expectation that the information communications industry will become a leading industry, replacing the steel and the auto industries. Other expectations are that productivity improvements and high value added products will be achieved by an information-oriented industry.^{*2)}

Japan cannot expect the high economic growth any longer which substantially existed before the oil crisis, and the information communications industry is expected to play an important role in launching economic restructuring. Additionally, the information communication society will have to deal with an aging society which is progressing faster than in other countries,^{*3)} reduce concentrations in Tokyo, and solve the problems of traffic/environmental problems accelerated by concentrations in Tokyo.^{*4)} Construction of information communications networks infrastructure provides various merits such as meeting an aged society, sound land

^{*1)}B-ISDN is a future telecommunication network and can combine various communication media, including voice, text, data and video via a common digital technology. On general explanations of B-ISDN, refer Ide (1993), Hori (1993), Mizuno (1993), Brownig (1993), Lipnack (1993), Victor (1993) and Oniki (1996). As its technical backgrounds, refer Ono (1993), MPT (1992 b), Asatani (1991), Curtis (1991), Grant (1993), Ohnishi (1991), Terada (1991) and Tokizawa (1991). CCITT (1990) is the document of B-ISDN's standardization by ITU. About studies of its introduction in Japan, refer MPT (Telecommunication Bureau) (1991), MPT (Communication Policy Bureau) (1992a), Communication Industries Association of Japan (1993), Oniki (1993) and MPT (1994). On its introduction policies of overseas, refer Yusei Kokusai Kyokai (1993). On its movements in U.S.A., refer Seki (1993), Elton (1991), Hollings (1991), Clinton (1993) and NTIA (1993). For Europe cases, refer Bonatti(1991). As to investment estimation of B-ISDN, refer Calabrese (1992), Egan (1992) (1995), Reed (1992) and Takasaki (1989).

^{*2)}The NII (National Information Infrastructure) concept of the Clinton Administration (1993) presents an information communications infrastructure which attaches significance to strengthening industry competitiveness and increasing employment opportunities.

^{*3)}Aged people who require care will reach 2 million, which is twice the current situation, in 2010. Japan will have a peak total population around 2010 with the decrease in the working age population.

^{*4)}The current situation is that 25% of the population is concentrated in the Tokyo area (Tokyo and the neighboring three prefectures).

management, measures for environmental problems and implementing a comfortable life style as well as restructuring the economy system.*⁵⁾ However, developing an interactive/broadband information communications network is a project requiring much time and money.*⁶⁾ Private companies may not be able to construct the infrastructure without public financial aids. So, it is worthwhile to calculate demands for interactive/broadband information communications networks, estimate the amount of investment for the infrastructure enough to supply these demands, and evaluate practicable private investments and indispensable public financial aids.

In analyses of the future telecommunications services, methods of estimation on demands for completely new services such as B-ISDN have not been established, so we will estimate them in two stages. First, we estimate demands for old media by applying the traditional telecommunications demands modeling techniques*,⁷⁾ and then calculate the switched demands from old media services by assuming the switch of media from conventional to new can be realized if the cost of the new media is lower than that of old. That is, demands for mobile communications, the Internet, conventional telephony are estimated by applying the conventional econometric models such as logistic or nonlinear regression models of GNP. Demands for interactive broadband ISDN such as video conference, visual telephone and video-on-demand (VOD) are calculated switched from old media's ones (conferences with traveling, face to face meetings or interviews with traveling and rental video). Models for estimating the amount of investment and calculating revenue and financial costs are conventional ones.*⁸⁾ Facility investment for new demand is obtained from the product of the unit cost of the facility investment per subscriber and the number of new subscribers. Effects of mass productions of facilities and equipment are considered by using the learning curve function to their unit costs.

In the next section, an econometric model is explained and its results of analysis are mentioned in section 3. In section 4, we summarize them as conclusion and calculation procedures of media switch are presented in the appendix.

2 Model of Telecommunication Industry

(1) Outline of Model

The telecommunication market in Japan is developing due to (1) high demand for the Internet,*⁹⁾ (2) high demand for mobile communication (cellular etc.),*¹⁰⁾ (3) effective use of the existing Narrowband ISDN,*¹¹⁾ (4) rather opaque demand for the so-called B-ISDN, and (5) steady spread of optical fibers in anticipation of rapid demand for optical communication.*¹²⁾

With the above considerations, we will make an economic model to describe telecommunication industry as Figure 2-1 shows. In this model, we predict some macro economic and social indices and estimate demands for telecommunication services. Then, investment which satisfies demand is estimated. Potential revenue is calculated under the present tariff system and operating and financial costs are estimated. The model does not deal with demand increase effects or free competition effects which can cause telecommunication service price reductions and subsequently increase demand for telecommunication services. But using the learning curve function, it does consider the effect of lowering the price of facilities and equipment as a result of mass production. Table 2-1 lists notations of main variables.

(2) Macro Economy

Population POP (thousand), working age population POPB (15-64 years old, thousand) and number of household HHD (thousand) come from the Ministry of Welfare's "Estimates of the future population, (1991)" and "Household projections for Japan by Prefecture: 1990-2010, (1993)".

*⁵⁾Telecommunication Council's proposal of December '93 advised to set the target period of infrastructure construction in 2010 when Japan will have a peak total population. It estimated 33 trillion yens investment cost, and calculated 123 trillion yens telecommunication related markets and 2.4 million workers employment through Input-Output analysis.

*⁶⁾Investment costs of constructing B-ISDN infrastructure amount from 2 to 90 trillion yens depending on scales and prices of facilities and equipment. Table in appendix (2) shows some main results.

*⁷⁾As the conventional telecommunications demands modeling techniques, refer Taylor (1994) and de Fontenay, Shugard and Sibley eds (1990).

*⁸⁾Many authors such as Reed (1992), Oniki and others (1993), Kobayashi (1994), Egan (1995) apply an engineering method to estimate the necessary amount of investment for constructing new infrastructures. Our revenue and financial model for the telecommunication service industries is a simplified one proposed by Oniki and others (1993) and Kobayashi (1994).

*⁹⁾In 1994, demand for the Internet and mobile communications began to rise up and Internet's and mobile communications' booms started.

*¹⁰⁾In May '95, Telecommunication Technical Council estimated the mobile communication demand and forecasted 32 million cellular and 38 million PHP subscribers.

*¹¹⁾In June '95, NTT expressed an introduction of Internet services in 1997 and an attitude of taking cost seriously.

*¹²⁾In December '94, NTT announced optical fiber construction plan. NTT will lay optical fiber to the nearest point of 20% residents, before 2000. Its investment costs will be 2 trillion yens.

Fig. 2-1 Infrastructure Analysis Model.

Table 2-1. Notations' List of Main Variables.

Y-	Number of subscribers-	T-	Time (Year).
CO-	Unit price of-	R-	Revenue of-
I-	New investment of-	S-	Share (rate)of-
II-	Renewal investment of-	-C	Mobile
K-	Capital stock of-	-J	Internet
D-	Depreciation or replacement rate of capital-	-E	Business
P-	Price of-	-H	Residential

An annual growth rate of real GNP (at 1985 constant price, billion yen) in real terms during 1996–2010 is expected to be 3.1%, and from 2011 it is expected to be 2.5%. Wages and incomes of the employed will grow at the same rate of GNP.

(3) Telecommunication Services Demand

Demand involves for mobile communication, the Internet, conventional public telephony, and interactive/broadband ISDN. There are many kinds of demands for Broadband ISDN, but demanded quantities are crucially depend on the media's communication quality, efficiency and price. To make the analysis objective, we analyze only three kinds of B-ISDN demands: video conference switched from conference with more than 30 minutes traveling, visual telephone switched from face-to-face meeting or interview with more than 30 minutes

traveling and video on demand VOD switched from conventional rental video. Demands for B-ISDN will be underestimated and the revenue will also be underestimated. But investment costs will basically depend on the penetration rate of B-ISDN and estimated amounts of investment will not show bias. So we will get rather reliable guides to profit and financial situations of telecommunication industries providing video conference, visual telephone and VOD services.

a. Mobile -C, -C1, -C2, -C3

Mobile communication are car and portable telephones (cellular)(-C1), pocket pagers (-C2) and Personal Handy Phones PHP (-C3). Demand for mobile communication is estimated with a logistic regression model.

YC: Mobile communication subscribers

$$= YC1(\text{cellular}) + YC2(\text{Pocket pagers}) + YC3(\text{PHP})$$

$$= 106,000,000 / (1 + \exp(4.27928 - 0.206861(T-1983)))$$

YC1: Cellular subscribers = $34,000,000 / (1 + \exp(7.24316 - 0.481388(T-1983)))$

YC2/(YC2 + YC3) = 0.98(in 1996) - 0.76(2000) - 0.47(2010-2025)

b. Internet -J, -J1, -J2, -J3

Internet users are estimated with a logistic regression model, (saturation levels are 30 million, that is, the number of host servers are 3 million).

YJ: Internet users or subscribers = $30,000,000 / (1 + \exp(4.493 - 0.209048(4(t-1991) + 3)))$

YJ1: Residential Internet users = $YJ * SJ1$

YJ2: Business Internet dial up IP connection users = $YJ * (1 - SJ1) * (1 - SJ3)$

YJ3: Business Internet dedicated line users = $0.1 * YJ$

SJ1: Residential Internet user's rate = $YJ1/YJ = 0.25(\text{at } 1996) - 0.68(2001) - 0.68(2025)$

SJ3: Dedicated line users' rate in business Internet users = $0.1 / (1 - SJ1)$

We think that "people will, sooner or later, be tired of the Internet. The amount of compatible information given through text files is limited. The Internet will not be as popular as expected because of its time-consuming properties". The number of subscribers is expected to reach all enterprises and every other household.

c. PSTN -E, -H

The number of business telephone subscribers YE (thousand) is the product of number of working age population POPB and number of business telephone subscriber per working population YE/POPB. The number of business telephone subscriber per working population YE/POPB is a linear function of real GNP per capita.

$$YE = POPB * (YE/POPB)$$

$$YE/POPB = 0.047895 + 0.0472939(GNP/POP)$$

Also, the number of residential telephone subscribers YH is the product of number of household HHD and the number of residential telephone subscriber per household YH/HHD. The number of residential telephone subscriber per household YH/HHD is a linear function of real GNP per capita transformed by Box-Cox transformation with parameter - 0.5.

$$YH = HHD * (YH/HHD)$$

$$YH/HHD = 0.133707 + 0.883410 * (((GNP/POP)**(-0.5) - 1) / -0.5)$$

d. BISDN -B, -B1, -B2, -B3

For video conference (-B1), visual telephone (-B2) and VOD (-B3), the switch of media from conventional to new can be realized if the cost of the new media is lower than that of the old as illustrated in Figure 2-2. A comparison of costs includes direct costs to use (equipment, traveling, basic charge and call rates), information transmission efficiency of the media, and loss of the opportunity cost due to traveling. Our assumption is that unit-time opportunity cost for individuals is proportional to the hourly income of the household and at enterprises it is proportional to the hourly wage of employees; the hourly wage and income follow a logarithmic normal distribution; coefficients of variation of wage and income distributions are constant over time; and the switch to the new media begins with individuals or employees having high opportunity costs. Then we can estimate a probability or a number of users switched from old media to new one. As wage increases, and cost changes, the number of users will increase like an S-shaped curve. Here, we assume the service charge of B-ISDN is two times of present telephone service charges. Calculation procedures are detailed in the appendix A.

(4) Telecommunication Service Model

a. Investment and Capital Stock I-, II-, K-

Mobile communication and telephone systems are assumed to be attributable to different service organizations. Telecommunication companies should provide the required service when demand occurs. The required facility investment has two classifications, i.e., investment for demand related to new subscribers and updating.

Facility investment (Iz) for new demand is obtained from the product of the unit cost of the facility invest-

Fig. 2-2 Media Switch.

ment per subscriber (CO_z) and the number of new subscribers ($Y_z - Y_z(-1)$). Where z shows the type of capital. Facilities deteriorate and need updating and the required investment for updating (II_z) is obtained by multiplying the estimate of the number of subscribers subject to update by a new unit cost.

$$I_z = CO_z * (Y_z - Y_z(-1))$$

$$II_z = CO_z * Y_z(-1) * D_z$$

$$K_z = (1 - D_z)K_z(-1) + I_z + II_z$$

Where D_z is the updating rate of z -type capital and K_z is the capital stock of z -type capital. Their parameters are set as in Table 2-2.

b. Unit Cost CO -

The unit cost of facility investment per subscriber is derived as follows. The unit cost of cellular ($COC1$) is a value which is obtained by dividing the stated, accumulated investment by the number of subscribers. In calculating the unit costs of pocket pagers ($COC2$) and personal handy phones ($COC3$), the basic charge ratio of cellular is used, assuming that these unit costs are proportional to the basic charge. The unit costs will decrease following the learning curve functions.

$$COC1 = 500,000 * ((YC1(-1) + YC1(-6) + \dots) / 6,000,000) ** (-0.4225)$$

$$COC2 = 100,000 * ((YC2(-1) + YC2(-6) + \dots) / (8,900,000)) ** (-0.3452)$$

$$COC3 = (500,000/3) * ((YC3(-1) + YC3(-6) + \dots) / (1,000,000)) ** (-0.3452)$$

For the Internet, adding DSU, D70 and ISM to the conventional wire line will be required when subscribing to INSnet 64 to access the Internet through dial up IP connection. The unit cost of facility investment of the dedicated line equivalent to INS64 is assumed to be same as INS64.

Unit cost of DSU, D70 and IMS

$$= (23,900 + 20,000 + 80,000) * (YJ1 * SJN1 + YJ2 * SJN2 + YJ3 * SJN3 + YC3/10) ** (-0.3452) \text{ yen}$$

SJN1: Rate of INS64 subscribers in residential Internet subscribers

$$= 0(\text{in } 1996) - 0.5(2008) - 0.6(2025)$$

Table 2-2. Depreciation and/or Renewal Rate of Capital.

	Mobile			Internet's facilities		
	Cellular	Podket Pagers	PHP	Residential INS64	Business INS64	Dedicated INS64
Depreciation rate	0.06	0.06	0.06	0.06	0.06	0.06
Initial value of capital stock 1995	1,070,500 million yens	807,000 million yens	0	0	0	520*(23.9 + 100) million yens

	Telephony Metal	BISDN SS; PDS local facility	SS; PDS local cable	SS; PDS transit system and cable
	DA	DBA	DBB	DBC
Depreciation rate	0.06 (Case 1, 2, 3) 0.06 – 0.2 (Case 4)	0 (1996–2005) 0.06 (2006–2025)	0 (1996–2005) 0.03 (2005–2025)	0 (1996–2005) 0.05 (2006–2025)
Initial value of capital stock 1995	14,300,000 million yens	0; 0	0; 0	1,000; 0 million yens

SJN2: Rate of INS64 subscribers in business Internet dial up users
= MIN(SJN1*4, 1)

SJN3: Rate of INS64 users in business Internet dedicated line users = 1

In the telephone system, three patterns are considered when newly installing or updating the line; (1) using the conventional metal line, (2) installing fiber optics in the neighborhood of the resident, and (3) installing B-ISDN. When installing fiber optics in the neighborhood, the 'PDS' passive double stars system will be considered. YR shows the number of PDS systems or the subscribers who locate near the PDS systems. The B-ISDN here is the SS single star system. YB shows the number of B-ISDN subscribers. Figure 2-3 shows the fiber optic systems and their unit costs of facilities and equipment. These are systems advocated by the Telecommunication Council's Report 1994.^{*13)} The unit costs are estimated at 2005 and more than 5 million new subscribers must appear at this time. In this paper, the unit cost of facilities, etc., is obtained from the learning curve function which presents the relationship between the increase in accumulated production and a lowered price. That is, the unit costs of local facilities of central office and residential equipment of PDS system (CORA) or SS system (COBA), and transit system and transmission cables of PDS (CORC) or SS system (COBC) are obtained from the learning curve function. But the unit costs of metal line (COA), local cables of PDS systems (CORB), and local cables of SS systems (COBB) are assumed constant since personnel expenses will increase in future occupies large proportion of installing cost. Using these parameters the learning curve function and unit costs are estimated using NTT and other data.

COA: Unit price of metal line = 250,000 yen

CORA: PDS local facilities = $145,000 * ((100,000 + YR(-1)) / 10,000,000)^{**} (-0.3452)$ yen

COBA: SS local facilities = $220,000 * ((100,000 + YB(-1)) / 10,000,000)^{**} (-0.3452)$ yen

CORB: Unit cost of PDS system local cables = 32,000 yen

COBB: Unit cost of SS system local cables = 132,000 yen

CORC: PDS transit system = $186,000 * ((100,000 + YR(-1)) / 10,000,000)^{**} (-0.3452)$ yen

COBC: SS transit system = $346,000 * ((60,000 + YB(-1)) / 10,000,000)^{**} (-0.3452)$ yen

c. Telephone System Infrastructure Scenario

The following four cases are different scenarios to help understand the effect of the policy which promotes the installation of optical fibers in telephone system facilities.

Case 1 concerns installing conventional wire line when updating common public telephones and installing new BISDN infrastructure. Updating rate is 6% every year. Case 1' is the special case of providing no BISDN services. It tells us the indispensable investment costs of and revenues from maintaining only PSTN.

Case 2 concerns installing optical fibers PDS system in the neighborhood of the resident when updating. Case 2' is the special case of constructing no BISDN services. It tells us the indispensable investment costs of preparing new PDS system.

Case 3 concerns the increase in video conference, visual telephone and VOD with an increasing consciousness of quality time by people. Updating rate of metal line is 6% as Case 1 and 2. The popularity rate greatly depends

^{*13)} Kobayashi (1994) studies the financial plausibility of this plan.

Fig. 2-3 The Local Fiber Optics Systems and Unit Prices of Facilities and Equipment.

on the consciousness of opportunity cost against traveling time (expressed as a reduction rate against wages). In Cases 1 and 2, the reduction rate is adjusted so that the number of users is equal to that of the existing users. With a change in reduction rate, the popularity rate significantly changes. According to a survey on the popularity of video conference, Yoshii (1991) stated that the problem is in the number of people against traveling and how to reduce their unfamiliarity with video conference. Analysis of the results with these people ranged from several percent to ten percent of the total.

In Cases 1 and 2, people who do not feel familiar with video conference is estimated to be about 2 percent and the corresponding reduction rate is 0.5. In Japan, traveling time except for business activity (nearly equal to commuting time) was 30 minutes on average in 1960, and increased to 70 minutes in 1990. With this rate of increase it may reach 83 minutes in 2000. In the year 2000, this will lead to more time-conscious people who desire efficient use of business hours. Case 3 assumes an elevation of the value of time with increasing commuting time.

Case 4 concerns the Ministry of Posts and Telecommunication's Policy to construct telecommunication infrastructure. Its moderate proposal is, in 2010, 21 million business subscribers with SS systems and 54 million residential subscribers with PDS system, and its total construction cost is about 33 trillion yens. We assume that the business and residential subscribers with PDS system increase with high rate of updating metal telephone systems begin from 6%, reach 20%, step by 2% each year. Differences between Case 3 and 4 show the policy effect and additional budget of promoting the infrastructure constructions.

YHA: Residential metal line subscribes = $YH - YB3$

YEA: Business metal line subscribes = $YE - \text{MAX}(YB1, YB2)$

YR: Number of PDS system installed instead of metal line

= $(YH(-1) + YE(-1) - YB - YR(-1)) \cdot DA + YR(-1)$, in Case 2

= $\text{MAX}((YR(-1) - XB), 0) + (YH(-1) + YE(-1) - YB - YR(-1)) \cdot DA$, in Case 3 or 4

IA: Investment for new metal line = $\text{COA} \cdot (YA - YA(-1))$

IBz: Investment for new SS system. component z

(z = A: local facilities; z = B: local cables; z = C: transit system and cables)

= $\text{COBz} \cdot (YB - YB(-1))$ in Case 1 or 2

= $\text{XB} \cdot (\text{COBz} - \text{CORz})$, if $YR(-1) > \text{XB}$ in Case 3 or 4

= $\text{XB} \cdot (\text{COBz} - \text{CORz}) + (\text{XB} - YR(-1)) \cdot \text{COBz}$, if $YR(-1) < \text{XB}$ in Case 3 or 4

Table 2-3. Parameters for Telecommunication Service Revenue.

unit:yen

	Sign-up fee	Basic charge	Time charge rate	Usage amount per year (minute per call *frequency per day*day)
Cellular	32,000	12*8,500	10*60/7 per minute	109/60*2*365
Pocket pagers	8,000	12*1,500	0	0*2*365
PHP	7,000	12*2,700	40/3 per minute	109/60*2*365
Residential INS64 (shift from conventional telephony)	0	((2830-1750) + 1700 + 60)*12(dif)	10/3 per minute	8*1*365
Business daial up INS64(shift)	0	((3630-2600) + 1700 + 60)*12(dif)	10/3 per minute	30*10*365
Business dedicated INS64(shift)	0	345,000*12(dif)	0	0*0*365
Residential telephone	72,000 + 800	1,750*12	46.37 per call	726 calls
VOD	102,000 + 800	1,750*12*2	3 per minute	1460 minutes
Business telephone	72,000 + 800	2,600*12	25 per call	2474.6 calls
video conference	(72,000 + 800)*2	2,600*12*2	150*30 per conference	2.34*12 conferences
visual telephone	(72,000 + 800)*2	2,600*12*2	30*30 per call	3.6*12 calls

dif: difference from telephony's charge

IIA: Renewal investment for metal line

$$= COA*(YH(-1) + YE(-1) - YB(-1) - YR(-1))*DA \text{ in Case 2, 3 or 4}$$

(5) Revenue Model on Telecommunication Services

The parameters for calculating telecommunication service revenue are estimated from present average values. Gross revenue is estimated from the sign-up fee [sign-up fee (PSz)* new subscribers], the basic charge [Basic charge (PFz)* total subscribers] and time charges [message rate (PVz)* total subscribers* frequency of use per subscriber (Fz)* subscriber average time per use (Tz)]. Consumption of services and the price of service charge rate are assumed to be constant over time expect business dedicated INS64 users' basic charge PFJ3. Table 2-3 shows parameters to calculate telecommunication services revenue.

RSz: Telephone sign up fee revenue from z subscriber (z = H: Residential telephone; B3: VOD; E: Business telephone; B12: Video conference and/or visual phone).

$$= \max(Yz - Yz(1), 0)*PSz$$

(RFH + RFB3): Residential telephone + VOD basic charge revenue

$$= (YH - YB3)*PFHA + YB3*PFB3$$

(RFE + RFB12): Business telephone + Video conf. and/or visual phone basic charge revenue

$$= (YE - \max(YB1, YB2))*PFEA + YB1*\max(YB1, YB2)$$

(RVH + RVB3): Time charge revenue from, Residential telephone and VOD

$$= (YH - YB3)*PVHA*FHA + YB3*(PVB3*TB3 + PVHA*FHA)$$

(RVE + RVB1 + RVB2): Time charge revenue from Business telephone, Video conference and Visual phone

$$= (YE - \max(YB1, YB2))*PVEA*FEA + YB1*(FB1*PVB1 + PVEA*FEA) + YB2*(FB2*PVB2 + PVEA*PEA)$$

$$RFJ3 = \min(PFJ3*(YJ1*SNJ1 + YJ2*SNJ2 + YJ3*SNJ3)/500,000)*(-0.3452), PFJ3)$$

(6) Operating Costs, Profit and Cash Flows Model on Telecommunication Services

The operating costs, profit and cash flows of the Telecommunication industries are calculated only for the public telephone service PSTN and B-ISDN as Figure 2-4 shows. The operating costs estimated are sum of labor costs and costs of supplies, and are the product of the number of subscribers for PSTN and B-ISDN and the average operating costs per subscriber. The average operating costs per subscriber (COST/(YE + YH)) is a function of penetration rate of them ((YE + YH)/HHD) (ratio of the number of subscriber divided by the number of household). In calculating the operating cost for each cases, three different average operating cost functions are used: In case 1, the cost function is set to be constant over time and for case 2, 3 and 4, two different cost functions are estimated with its minimum average cost level to be 30 thousand yens in case 2, 10 thousand yens in case 3 and 4.

$$COST_i: \text{Operating costs of case } i = (YH + YE)*(COST_i/(YH + YE))$$

$$COST_i/(YH + YE): \text{Average operating costs per subscriber for case } i$$

$$= 50.83 \text{ thousand yens}$$

(Case 1)

$$= 10 + 10*\exp(1.550772)*((YH + YE)/HHD)**(-0.5289)$$

(Case 3, 4)

$$= 30 + 10*\exp(1.745)*((YH + YE)/HHD)**(-0.4636)$$

(Case 2)

Fig. 2-4 Cash Flows of Telecommunication Industry.

As a guide of evaluating the model, the labor costs are also calculate as a product of the numbers of employee and average wage per employee. Wages will grow up with the same growth rate of GNP. The number of employee (L) is calculated dividing the number of subscriber ($YH + YE$) by the number of subscriber per employee ($(YH + YE)/L$); productivity of employee. And productivity of employee is estimated as quadratic function of time.

$$L = (\text{Number of subscriber}) / (\text{Number of subscriber per employee})$$

$$= (YH + YE) / ((YH + YE) / L)$$

$$(YH + YE) / L = 4927163.6 - 4969.852 * \text{YEAR} + 1.2532639 * \text{YEAR}^2$$

Profit (PAI) from operating PSTN and B-ISDN is calculated by deducting the operating costs (COST), depreciation of capital stock ($D * K$), unnecessary capital stock of old PSTN metal line system (SKA) and interest payment ($r * \text{BOND}$) for accumulated debts (BOND) from the operating income (R (revenue)). The interest rate (r) is 6.2%.

$$\text{PAI} = R - (\text{COST} + D * K - r * \text{BOND} + \text{SKA})$$

$$\text{SKA: Unnecessary capital stock of metal line system} = (1.0 - \text{DA}) * \text{KA}(-1) - \text{KDA}$$

$$\text{KDA: Necessary capital stock for metal line system} = 250,000 * (YH + YE - YB - YR)$$

Surplus funds (SURFUND) are defined as amounts of deducting operating costs (COST), total investment costs (I) and the interest payments ($r * \text{BOND}$) for the accumulated debts from total revenue (R). The accumulated debts (BOND) is defined as sum of surplus funds from 1996 and set to be equal to bonds issued.

SURFUND: Surplus funds for PSTN and B-ISDN supplier

$$= R - (\text{COST} + \text{total I} - r * \text{BOND})$$

$$\text{BOND: Accumulated debts: bonds issued from 1996.} = \text{BOND}(-1) + \text{SURFUND}$$

3 Result Of Analysis

(1) Macro Indexes

Table 3-1 shows, in 2010, Japan will have 678 trillion yens GNP, 130.3 million population, 50.6 million households, 81.3 million working age population, and 80.9 million subscribers for PSTN and B-ISDN, (56.5 million residential subscribers and 24.4 million business subscribers).

Table 3-1. GNP, Population and Subscribers.

(trillion yen and million)

	GNP	Population	Household	Pop Work	Subscriber	Sub h	Sub b
1996	442.6	125.7	44.0	86.8	61.4	42.2	19.1
2000	500.1	127.3	46.1	86.4	67.3	46.6	20.7
2005	582.6	129.3	48.4	84.4	74.2	51.7	22.5
2010	678.6	130.3	50.2	81.3	80.9	56.5	24.4

Table 3-2. Mobile Communication.

	Subscribers million	Unit cost (cellular) thousand yen	Investment billion yen	Capital stock billion yen	Revenue billion yen
1996	18	416	31	1,795	2,155
2000	34	276	1,494	7,022	5,659
2005	60	192	960	8,358	7,969
2010	83	158	686	8,329	9,072
Total 1969/2005			11,729		55,823

Table 3-3. Internet

	Subscribers million	Unit cost thousand yen	Investment billion yen	Capital stock billion yen	Revenue billion yen
1996	3	120	37	98	2,256
2000	22	38	120	475	6,117
2005	30	30	59	693	6,708
2010	30	28	37	722	6,656
Total 1996/2010			1,109		87,553

(2) Mobile Communication

Table 3-2 shows the results of predictions about mobile communication. Subscribers in mobile communication will exceed half of the upper limit of market saturation, 105 million in 2004. The unit costs of cellular, pocket pager's and PHP's facility investment per subscriber will go down to one third of present cost in 2010. In order to meet quickly increasing demand, investment will exceed 1 trillion yens every year to 2004, and after 2005, investment for renewal will prevail.

Total revenue of mobile communication will rise from 2.1 trillion yens in 1996, 5.6 trillion in 2000 and to 9 trillion yens in 2010. Accumulated total investment cost to 2005 is 11.7 trillion yens and accumulated total revenue is 55.8 trillion yens. Mobile communication is a primary growth business.

(3) The Internet

Table 3-3 is the results of predictions about the Internet. Users of the Internet will be 3 million (nearly equal to the number of present personal computer communication subscribers) in 1996, 22 million in 2000 and reach to the saturation limit 30 million in 2010. The Internet boom will be over in 4 or 5 years.

After 2 to 3 years experience connecting to the Internet, there will be a prominent migration to higher speed INSnet 64 etc. Subscribers of INS64 will amount to 230 thousand in 1996, 6 million in 2000 and 18 million in 2010. These Internet users are considered to be potential users of high-speed optical fiber networks. Unit price of facilities for INSnet 64 will go down to one fifth of present price because penetration of PHP will accelerate its speed.

Additional investment is small in amount, but revenue will amount to large. More than 90% of revenue will come from business users. The basic charge rate for the Internet will decrease drastically and cease to be a burden on family budgets. Average revenue from residential users divided by the total number of households will be 4,700 yen in 2000. It equals to 7% of communication expenditures of present household and will be reasonable additional expenses to household.

The Internet is a very profitable business and its service price is expected to decrease drastically.

(4) Demand for Common Public Telephone

a. Video Conference And Visual Telephone

In Case 1 or 2, subscribers for video conference will amount to 17 thousand in 1996, 36 thousand in 2000, and

4.38 million in 2010 as Table 3-4 shows. In 2007, a half of establishments will be a subscribers of B-ISDN. Visual phone subscribers will amount to 3 thousands in 1996, 8 thousand in 2000, and 79 thousand in 2010, and exceed a million after 2015. In Case 3 or 4, subscribers of video conference and visual telephone will be 17 and 3 thousand, respectively, in 1996, 36 and 8 thousand in 2000, and 4.7 million and 778 thousand in 2010.

b. VOD.

Demand for VOD will not increase rapidly because of low rental video shop's price, technical progress of telecommunication and the user's low evaluation of opportunity cost. In Case 1 or 2, subscribers of VOD will amount to 53 thousand in 1996, 892 thousand in 2000, and 8.8 million in 2010. In Case 3 or 4, subscribers will amount to 53 thousand in 1996, 892 thousand in 2000, but 17 million households in 2010.

c. Telephony

Total subscribers to PSTN and B-ISDN (Table 3-1) will number 61.4 million in 1996, 67.3 million in 2000, 74.2 million in 2005 and 80.9 million in 2010. Penetration rate of new telephone system (Table 3-4) in Case 1 will be 0.1% in 1996, 1.3% in 2000, 6.5% in 2005 and 11% in 2010. In Case 2, penetration rate of new telephone system including updated PDS systems will amount to 26.3% in 2000, 47.5% in 2005, and 61% in 2010, leaving around 40% metal lines. (Refer Figure 3-1.) But in Case 3, penetration rate of new system will be 25.3% in 2000, 40.4% in 2005 and 49.1% in 2010. (Refer Figure 3-2.) In Case 2, SS systems and PDS systems are independently installed, but in Case 3, PDS system can shift to SS system with additional investment expenditure. So, the penetration of B-ISDN of Case 3 becomes lower than that of Case 2.

In Case 4, the penetration rate of new system will be 39.3% in 2000, 73.4% in 2005, and 83.1% in 2010. (Refer Figure 3-3)

c.1 Unit Cost of Facilities

Unit cost of SS and PDS systems will fall as Table 3-5. The SS-system will cost twice that of metal (250 thousand yens) in Case 3 and 4. But, unit costs of PDS system will fall under metal's by 2010 in Case 2 and 4. In Case 4, PDS will become cheaper than metal system in 2000, because of its mass production.

c.2 Investment Cost and Capital Stock

Average investment expenditures and accumulated total expenditures from 1996 to 2010 will amount as Table 3-6. Amounts of investment expenditures and capital stock include the expenditure for the Internet. Case 1, 2 and 3 are practically same. In Case 3 and 4, PDS system installed earlier can be used to construct SS system with additional cost. In case 2 and 3, demands for B-ISDN of Case 3 are larger than that of Case 2 and mass production effects work in Case 3. Then, Case 3 will be the most efficient. Accumulated total investment expenditures of Case 3 will be 2 trillion yens lower than Case 1 of updating metal line and around 3.6 trillion yens lower than Case 2. Case 4 costs 10 trillion yens more than Case 1 and 12 trillion yens more than Case 3. This cost cor-

Fig. 3-1 Subscriber Case 2.

Fig. 3-2 Subscriber Case 3.

Table 3-4. Subscribers of Video Conference, Visual Phone and VOD.

(thousand)

	Video Con.		Visual Phone		VOD		SS %		PDS %		
	Case 1, 2	Case 3, 4	Case 1, 2	Case 3, 4	Case 1, 2	Case 3, 4	Case 1, 2	Case 3, 4	Case 2	Case 3	Case 4
1996	17	17	3	3	53	53	.1	.1	1	6	6
2000	36	36	8	8	892	892	1.3	1.3	25	24	38
2005	988	1,478	27	48	4,824	7,728	6.5	10.4	41	30	63
2010	4,380	4,739	79	778	8,876	17,088	11	21.1	50	28	62

Table 3-5. Unit Cost of SS-system and PDS-system.

(thousand yen)

	Case-1, 2	Case-3	Case-4	Case-1, 2	Case-3	Case-4
1996	2,578	2,578	2,578	464	464	464
2000	1,384	1,384	1,384	303	308	269
2005	791	701	701	255	279	225
2010	608	534	534	235	278	220

Table 3-6. Average Investment Expenditure per Year.

(billion yen)

	Case-1'	Case-1	Case-2'	Case-2	Case-3	Case-4
1996/2000	1,381	1,615	1,766	2,000	1,940	3,241
2001/2005	1,270	1,923	1,142	1,797	1,630	2,293
2006/2010	1,315	2,189	1,355	2,276	1,784	2,181
Total 1996/2010	19,830	28,640	21,318	30,367	26,768	38,573

responds to the speech, "If 10 trillion yens is available, a optical fiber network can be installed", expressed by the Ministry of Posts and Telecommunications in 1994. Some policy will be necessary to promote infrastructure construction.

In case of capital stock, all Cases will amount nearly same. Figure 3-4, -5 shows movements of capital stock in Case 3 and 4.

Case 1' shows the investment expenditures to install only metal line system. Its costs will amount to around 20 trillion yens to 2010. If we may think this 20 trillion yens as a indispensable costs to private telecommunication industries, additional investment costs to construct B-ISDN infrastructure will be from 6 to 20 trillion yens de-

Fig. 3-3 Subscriber Case 4.

Fig. 3-4 Capital Stock Case 3.

pending on the desired penetration level.

c.3 Revenue and Profitability

Table 3-8 shows average annual revenues and accumulated total revenues from 1996 to 2010. Case 1 and Case 2 have same numbers, and Case 3 and Case 4 have same numbers. Revenues from Internet are quite large in amount. Compared with investment expenditure in Case 3, revenue will support the investment for infrastructure. Revenue from the Internet services will be promising to construct infrastructure and finance the cost of building infrastructure, if there is no service price reduction. But this scenario is unrealistic and any financing system will be necessary to complete telecommunication infrastructure before 2010: the time that the population will begin to decrease.

In calculating profits and surplus funds, the annual interest rate for bonds issued is set to be 6.2%. Table 3-9 ~ 3-18 show the costs of operating telecommunication services, profit and cash flow of telecommunication industry. Table 3-11 shows that the profits of Case 1, 2 and 3 will be positive, but in Case 4 it will be negative be-

Fig. 3-5 Capital Stock Case 4.

Table 3-7. Capital Stock.

	(billion yen)			
	Case-1	Case-2	Case-3	Case-4
2000	18,465	20,446	20,144	20,301
2005	23,738	26,010	24,833	24,924
2010	28,486	30,057	27,826	27,894
2025	39,190	38,728	36,879	39,128

Table 3-8. Average Annual Total Revenue.

	(billion yen)					
	Include		Internet			
	Case-1'	Case-1, 2	Case-1, 2	Case-1'	Case-3	Case-3 inc. Internet
1996/2000	4,380	4,423	10,760	10,674	4,423	10,760
2001/2005	4,841	5,269	13,399	12,545	5,513	14,000
2006/2010	5,282	7,689	18,536	13,722	8,322	19,802
Total 1996/2010	72,517	86,906	213,480	184,701	91,296	222,260

fore 2005.

Table 3-12 shows that the surplus funds will be negative in 2000, but change to positive by 2005, in all cases.

Table 3-15 and Figure 3-6 and -7 show the results of the accumulated debts. Accumulated debt of Case 1 will attain its peak (− 4,265 billion yens) in 2004 and will be paid off (543 billion yens) in 2009. In Case 2, it will attain its peak (− 6,289 billion yens) in 2004 and will be paid off (1,044 billion yens) in 2010. In Case 3, it will attain its peak (− 4,136 billion yens) in 2002 and will be paid off (1,935 billion yens) in 2007. In Case 4, it will attain its peak (− 16,186 billion yens) in 2004 and will be paid off (4,400 billion yens) in 2013. If the penetration rate of new telephone system B-ISDN composing of SS- and/or PDS-system will be lower than around 80% in 2010, the outstanding bonds or accumulated debt will be paid off by around the year of 2010. If we consider the necessary financial cost as the maximum bonds of Case 4, necessary financial aid will amount 12 trillion yens.

4 Conclusion

Conclusions obtained from analysis are as follows.

- 1) Investment costs for telecommunication infrastructure are decreasing because of technical progress. But

Table 3-9. Depreciation of Capital Stock and Unnecessary Capital.
(billion yen)

	Case-1	Case-2	Case-3	Case-4
1996	858	858	858	2,860
2000	732	777	728	1,767
2005	854	606	612	983
2010	1,366	1,562	1,380	1,637

Table 3-10. Interest Payment for Accumulated Debts.
(billion yen)

	Case-1	Case-2	Case-3	Case-4
1996	0	0	0	0
2000	- 94	- 216	- 185	- 567
2005	- 264	- 390	- 207	- 1,004
2010	34	- 97	545	- 676

Table 3-11. Profit
(billion yen)

	Case-1	Case-2	Case-3	Case-4
1996	193	193	270	- 1,732
2000	440	319	499	- 920
2005	1,059	1,290	2,107	939
2010	333	3,180	4,780	3,303

Table 3-12. Surplus Funds.
(billion yen)

	Case-1	Case-2	Case-3	Case-4
1996	- 884	- 1,660	- 1,582	- 3,584
2000	- 619	- 806	- 484	- 1,886
2005	72	304	1,363	160
2010	2,602	2,605	4,446	2,955

Table 3-13. Average Operating Costs per Subscriber.
(thousand yen)

	Case-1	Case-2	Case-3, 4
1996	50.8	50.8	49.6
2000	50.8	50.1	48.6
2005	50.8	49.4	47.6
2010	50.8	48.7	46.6

Table 3-14. Operating Costs.
(billion yen)

	Case-1	Case-2	Case-3, 4
1996	3,119	3,119	3,041
2000	3,419	3,372	3,271
2005	3,772	3,664	3,533
2010	4,114	3,938	3,773

Table 3-15. Accumulated Debts.
(billion yen)

	Case-1	Case-2	Case-3	Case-4
1996	- 884	- 1,660	- 1,582	- 3,584
2000	- 2,127	- 4,292	- 3,480	- 11,031
2005	- 4,193	- 5,986	- 1,968	- 16,027
2010	3,145	1,044	13,230	- 7,953

Fig. 3-6 Debt Case 1, 2.

Fig. 3-7 Debt Case 3, 4.

the speed of computer technology is higher than that of telecommunication. Personnel costs of telecommunication services are burden on the race. Computer technology catches communication technology.

2) Mobile communication is a primary growth business. Demand for mobile communications will continuously increase for a relatively longer period. Investment for mobile communications will increase for several years.

3) The Internet is a very promising business. Its boom will be over in 4 or 5 years. The Internet users are considered to be potential users of high-speed optical fiber networks. Revenue from the Internet will be very large in amount, but the basic charge rate for the Internet will decrease drastically and cease to be a burden on family budgets. N-ISDN networks will supply the Internet services.

4) Demands for the Internet and mobile communications can produce surplus funds which may be appropriated for a telephone system replaced by an optical communication system.

5) If a wire line is renewed by optical cable, the investment will be less, compared to the case of replacing

Table 3-16. Number of Employee.
(thousand)

Case-1, 2, 3, 4	
1996	169
2000	131
2005	97
2010	75

Table 3-17. Average Wage Rate.
(thousand yen)

Case-1, 2, 3, 4	
1996	9,660
2000	11,930
2005	15,520
2010	20,190

Table 3-18. Labor Cost and its Percentage of Operating Costs.

(billion yen, %)						
	Case-1	(%)	Case-2	(%)	Case-3, 4	(%)
1996	1,483	(52.4)	1,483	(52.4)	1,406	(53.8)
2000	1,862	(45.5)	1,815	(46.2)	1,714	(47.6)
2005	2,262	(40.0)	2,154	(41.2)	2,022	(42.7)
2010	2,590	(37.0)	2,414	(38.7)	2,249	(40.3)

with a wire line. Penetration rate of new telephone system will be around 60% in 2010, if 6% updating policy is adopted. If we want to prepare 100% information infrastructure before 2010 for universal service and so on, we will need any policy to invest in unprofitable area. Its public financial cost will be around 10 trillion yen.

6) The value of time will increase for people with large commuting time, and the time-saving limits on mobile communication and popularity of handling the Internet will lead demand toward B-ISDN. Consequently, from about 2005, demand will largely shift to B-ISDN. But the building of infrastructure to cope with Japanese economic and social difficulties will not be in time for 2010. The infrastructure accelerating policy will begin after present Internet and mobile communication booms. Investment for B-ISDN will accelerate from about 2000.

7) If we adopt the 20% updating policy, infrastructuring for optical communication will penetrate more than 80% in 2010, and the outstanding bonds or accumulated debt will be paid off by around the year of 2010. If we consider the necessary financial cost as the maximum bonds of Case 4, necessary financial aid will amount 12 trillion yens. Judging from other criteria such as the necessary investment costs, we may estimate that the public financial cost will be from 6 trillion yens to 25 trillion yen depending on policies.

8) High demand for B-ISDN appeared in early stages has the strong effect to reduce the unit cost of equipment and facilities to construct B-ISDN infrastructure. And it is desirable to begin the projects of constructing telecommunication infrastructures as early as possible for stimulating the learning curve's effect.

5 Appendix

(1) Media Switch

Let's us consider a cost of using old media Om

$$X_o = (P_{om} + W_i \cdot e \cdot t_{om}) / C_{om},$$

and one of using new media Bm

$$X_b = (P_{bm} + W_i \cdot e \cdot t_{bm}) / C_{bm}.$$

Where P_{om} is cost of using Om, P_{bm} is cost of using new B-ISDN media Bm, t_{om} (t_{bm}) is useless time in use of Om (Bm), C_{om} (C_{bm}) is communication efficiency of Om (Bm), W_i is hourly wage rate or income for individual i , and e is discount rate of time-value or opportunity cost rate (i.e. opportunity cost = $e \cdot W_i$). The e is assumed to be constant for all individual. We assume that a person whose wage rate satisfies the condition $X_o > X_b$, switches from a old media Om to a new media Bm.

In calculation, we estimate the switching wage rate W , which equate X_o and X_b and estimates the probability that wage rate is higher than W . The switching wage rate equations and their parameters are as follows.

Interactive/Broadband communication, B-ISDN -B, -B1, -B2, -B3

YB: B-ISDN subscribers = MAX(YB1, YB2) + YB3

YB1(or 2): Video conference (Visual phone) subscribers switched from conference (meeting) with more than 30 minutes traveling.

$$W1, 2: \text{Switching wage rate in case of Video conference, (Visual Phone)} \\ = (((12 * M * T_{meet} * P(Tt) * Svc * N * Rvc) / Evc) + Fvc * Dvc) \\ - (2 * 12 * M * C(Tt) * N * Svc * Rvc / E0)) / (2 * 12 * M * Tt * N * Svc * Rvc / E0) / Op$$

Where M: Numbers of conference (meeting) with more than 30 minutes traveling per month and worker = 3.8 Video Conference, (6 Visual phone). Tt: Traveling time of conference (meeting) = 100, (100) minutes/each way. Tmeet: Conference (meeting) time = 150, (30) minutes/each. C(Tt): Traveling cost of Tt minutes travel = 14,559, (14,559) yens/each. P(Tt): Long distant call time charge for Tt minutes traveling distant = 30, (30) yens/minute. Svc: Probability of Video conference (visual phone) substitutability = 0.107, (0.107). Rvc: Proportion of preferring video conference (visual phone) = 0.05, (0.05). E0: Communication efficiency of face to face conference (meeting) = 1, (1). Evc: Communication efficiency of video conference (visual phone) = 0.65, (0.65). N: Number of shared users in an establishment = 5, (1). Fvc: Price of video conference (visual phone) equipment = 2,260,000, (600,000) yens. Dvc: Depreciation rate of video conference (visual phone) equipment = 0.369, (0.369). Op: Opportunity cost parameter = 0.5, (0.3).

Coefficient of variation of wage distribution = 985.30/1850

YB1, 2 = (Numbers of workers whose wage rate are larger than W1, 2)/N

YB12: Business subscribers of B-ISDN = MAX (YB1, YB2)

YB3: VOD subscribers switched from rental video with 30 minutes traveling.

$$W3: \text{Switching hourly household income in case of VOD,} \\ = (((Bbcharge + Fvod / Lvod) / Hz + (Psvod * T_{watch} / Tt + T_{watch} * P(Tt))) / Evod) \\ - (Fv / Lv / Hz + Psoft * T_{watch} / Tsoft) / E0) / (Tt * T_{watch} / Tsoft / E0) / Op$$

Where Hz: Household's size, Tt: Traveling time to video rental shop = 30 minutes/each. Twatch: Annual watching time of Video soft = 1460 minutes. Tsoft: Average minutes of watching a soft = 75 minutes. P(Tt): Time charge of watching Video soft = 3.3 yens/minute. Bbcharge: B-ISDN basic charge = 1.5 * Basic telephone charge = 1.5 * 25,200 yens/year. E0: Efficiency of rental video = 1. Evod: Efficiency of VOD = 1. Fvod: Price of VOD equipment = 300,000 * (YB3 - 1) / 50,000 * (-0.4225). Fv: Price of video equipment = 75,657 * (1 - 0.0266) * (T - 1995). Lvod: Life time of VOD equipment = 10 years. Lv: Life time of video equipment = 6 years. Psoft: Rental price of video soft = 280 yens/each. Psvod: Price of VOD services = 1/3 * Psoft. Op: Opportunity cost parameter = 0.46.

Coefficient of variation of income distribution = 602.33/1584.45

YB3 = Numbers of households whose hourly incomes are larger than W3.

(2) Investment Estimations of B-ISDN Infrastructure

Necessary investments to construct B-ISDN infrastructure in Japan have been estimated by MPT and/or NTT. Its estimated values went up in the early stage and began to go down from 1994 as follows.

Year	Estimators	Investment Cost trillion yens	Scales of Subscribers	Target Period	Note
1988	MPT	4.5	20 million		N-V system - 1.5 Mbps. Adjusted to our definition
1990	NTT		100% Fiber To The Home	2015	VI & P Information service plan
1991	MPT	33	77%	2015	B-ISDN
1992	Oniki and others	72	75% (2015)	1996 ~ 2025	N- and B-ISDN
1994	Kuriyama, Oniki and others	90		1996 ~ 2025	N- and B-ISDN. Integrate Oniki's supply model (1992) and Kuriyama's demand model (1993). B-ISDN service prices are twice the present prices.
1993	MPT	33 53	21 million SS 54 million PDS 75 million SS	2010	B-ISDN Single Star and Passive Double Star system.
1994	NTT	45	FTTH	2015	
1994 July	MC	40	All over the country	2000	Construct the information ducts to install optical fibers.
1994 July	MPT	10			
1994 Dec.	NTT	2	20%	2000	Lay optical fiber to the nearest point of residents.

MPT: The Ministry of Posts and Telecommunications.

MC: The ministry of Construction.

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