CHAPTER 20
Economic And Financial Evaluation

20. ECONOMIC AND FINANCIAL EVALUATION

20.1. INTRODUCTION

Both the trunk bus system project and the road projects are evaluated in this chapter, from the economic and financial viewpoints. The economic evaluation is to examine the economic viability of a project by comparing economic cost of the projects and economic return (so-called social benefits) to be generated in the regional or national economy by the projects, while the financial evaluation is to analyze profitability of a project to the operating agency, through comparison of revenue and expenditure.

While there are many differences between the economic and the financial evaluations, the most essential is their standpoints. The economic evaluation is made from the standpoint of the regional economy and the financial evaluation is from the standpoint of specified stakeholders—the trunk bus company in this study. Subsequently, the cost and benefit in the economic evaluation are measured by the economic price, and the cost and revenue in the financial analysis are measured by the market price. (Table 20.1-1)

The economic project life is assumed to be 25 years for the road projects and 15 years after full operation for the trunk bus system project. The latter is a software project to plan how to efficiently use the limited road space, and the operation of the trunk bus service can be terminated anytime depending on the situation. Accordingly, its project life is assumed to be shorter.

Table 20.1-1 Economic vs. Financial Evaluation

	Economic Evaluation	*Financial Evaluation*
Project	Trunk Bus System + Road	Trunk Bus System
Viewpoint	Regional Economy	Bus Operator (Bus Company)
Investor	Government	Private Sector
Evaluation Method	• Cost / Benefit Analysis • With / Without Comparison • Economic Price	• Cost / Profit Analysis • Analysis of Financial Statement • Market Price
Inflation & Tax	Not accounted for	Accounted for
Direct Beneficiaries	• Car & Bus Users	• Stockholders • Financiers • Employees

20.2. ECONOMIC EVALUATION

20.2.1. APPROACH AND ASSUMPTIONS

In this section, the trunk bus system project and the road projects are evaluated from the economic viewpoint, following a normative method of the cost-benefit analysis. To measure and compare cost and benefit of the projects in economic price, the procedure shown in Figure 20.2-1 was taken.

Economic cost is a monetary expression of goods and services really consumed for a project implementation. Then, all the transfer cost (tax and subsidy) will be deducted from the cost measured in market price. In addition, shadow wage rates (SWRs) are applied to unskilled labor costs included in the project cost. The same process is taken to estimate unit cost of vehicle operation, which is used for estimation of economic benefits, by excluding all taxes and applying the SWRs to labor cost of mechanics and crews.

The implementation program shown in Chapter 18 is preconditioned to identify the year when the project cost is generated or the benefit starts to accrue, because the evaluation results are affected by changes of the implementation program

Economic benefit is defined as an amount saved in travel costs by a project. Travel costs consist of two components, vehicle operating cost (VOC) and travel time cost (TTC). These are the most direct benefits and are comparatively easy to quantify. Obviously, in a transportation project, other benefits exist besides those direct benefits, such as safety improvement and acceleration of urban development, as well as mitigation of traffic congestion. In this feasibility study, however, those kinds of difficult-to-measure benefits are neglected to prevent an arbitrary evaluation.

The benefit of a project is measured through so-called “with” and “without” comparison. Using the results of traffic assignment to a network with the project in question and also to the same network but without the project, total VOC and TTC of each case are calculated. Then, the benefit is obtained as the difference between the “with” and “without cases.

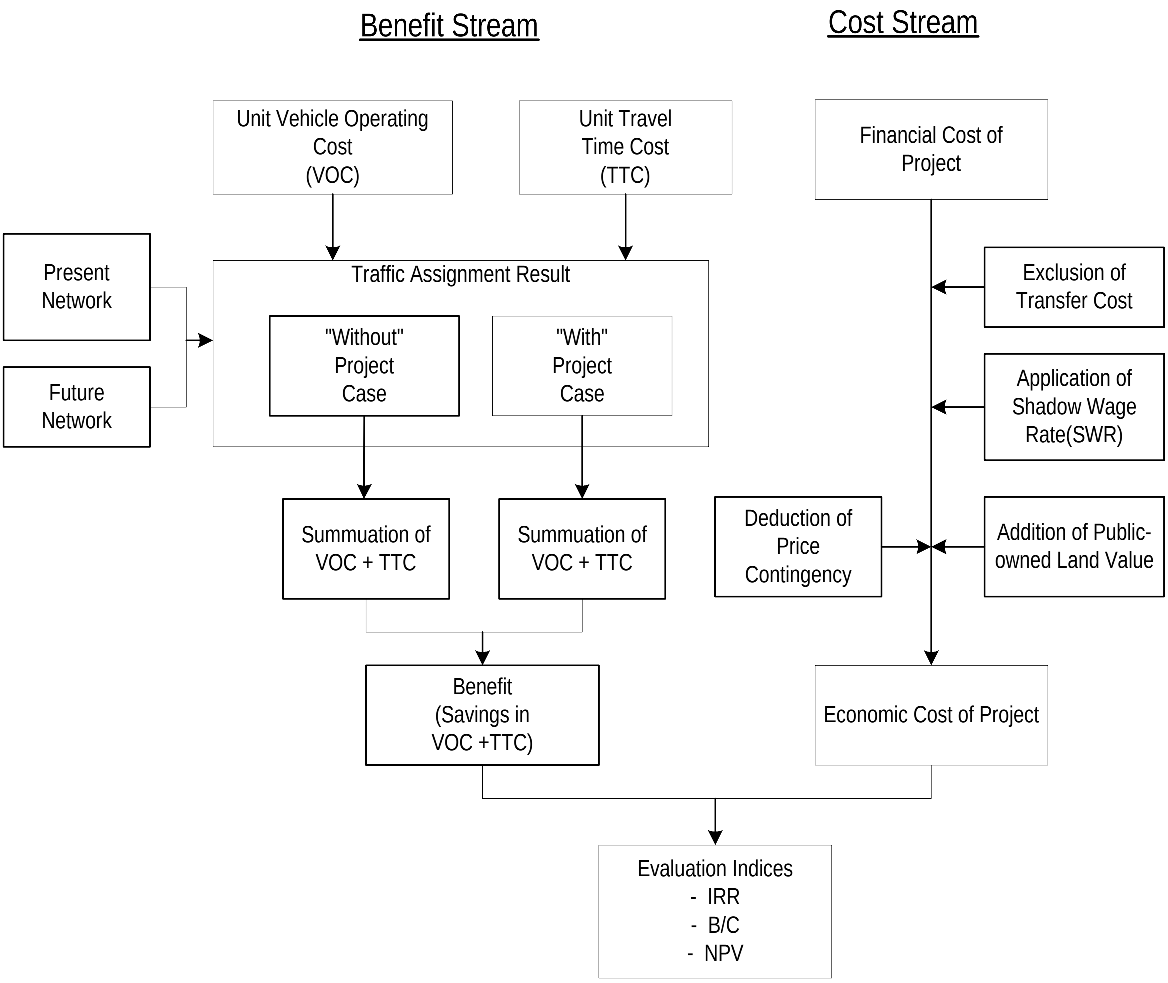


Figure 20.2-1 Work Flow for Economic Evaluation

Economic cost and benefit are compared through a discount cash flow analysis. The discount rate (DR) is 12%, which is widely used in Brazil as an economic interest rate. The same rate is used in estimation of capital opportunity cost of VOC. As evaluation indicators, internal rate of return (IRR), benefit/cost ratio (B/C) and net present value (NPV) are calculated. They are defined as below:

- Internal Rate of Return (IRR): r satisfying: $\sum \frac{B_n}{(1+r)^n} = \sum \frac{C_n}{(1+r)^n}$
- Net Present Value (NPV) = $\sum \frac{B_n - C_n}{(1 + DR)^n}$
- B/C Ratio (B/C) = $\sum \frac{B_n}{(1+DR)^n} \div \sum \frac{C_n}{(1+DR)^n}$

20.2.2. ECONOMIC COST

Project costs stated in Chapter 16 are expressed in the financial price (at market price) and were converted into economic cost, through the following process.

1) Direct construction cost was broken down into three cost items: material cost, equipment machinery cost and labor cost, assuming 60% for material cost, 30% for equipment and machinery cost and 10% for labor cost.
2) Out of material and equipment cost, the following taxes were deducted.
   - Equipment and Services
     - Tax on Industrial Goods (IPI) 12 %
     - Tax on Circulation of Goods and Services (ICMS) 12 %
     - Tax on Services (ISS) 5 %
   - Materials
     - Tax on Circulation of Goods and Services (ICMS) 17 %
     - Tax on Services (ISS) 5 %

   The IPI is a federal government tax, the ICMS is a state tax and the ISS is a municipal/county tax, respectively.
3) According to the PNAD/IBG's homepage information, the unemployment rate in the Belem Metropolitan Area is estimated very high at 14.0%. Assuming that the high rate will last during the implementation period, a shadow wage rate (SWR) was estimated at 55% according to the Haveman's formula:

   SWG = (Wage rate in market) x (1.25 – Unemployment Rate / 0.2)

   = (Wage Rate in market) x 0.55

   Wage to unskilled laborers was assumed at 60% of total labor cost.
4) Half of the contingency is regarded as the price contingency, which should be deducted from the economic cost. The other half is the physical contingency, which is to be accounted in the economic cost.
5) Out of eight terminals, the two terminals of C (Mangueirao) and H (Independencia2) were planned to use land lots owned by the state government, so the land costs were not counted in the financial cost estimated in Chapter 16. They should be included, however, in the economic cost. Those two lots were appraised at R$217,000 for Terminal C and R$129,000 for Terminal H.

Table 20.2-1 shows the resultant economic cost of the study projects. The total economic cost of the trunk bus system and the road projects is R$785.4 million, 80% of the financial costs. Here, the road project cost includes, for evaluation, the cost of four-lane road construction of Independencia, which was excluded in Chapter 16 because Para State already committed to its construction.

The total land cost of the eight terminals is R$1.24 million, exclusive of compensation cost for properties. As the land is not a depreciable asset, the amount was refunded in the cash inflow in the year 2027.

Table 20.2-1 Financial Cost and Economic Cost of Project

Project			Financial Cost		Economic Cost		Economic/ Financial Rate
			(1) including Extra Work	(2)excluding Extra Work	(1) including Extra Work	(2)excluding Extra Work	
Trunk Busway	1	Av.Almirante Barroso	51,867	30,148	40,546	23,568	0.78
	2	BR316	94,073	71,690	73,540	56,042	0.78
	3	Rod.Augusto Montenegro	100,489	66,672	78,555	52,119	0.78
	4	Av.Independencia on suburban segment	70,300	70,300	58,614	58,614	0.83
	5	Av.Independencia on central accessing segment	62,496	62,496	51,035	51,035	0.82
	6	Icoaraci Area	1,439	1,439	1,125	1,125	0.78
	7	Centro Area	6,212	6,212	4,856	4,856	0.78
	8	Mario Covas	3,552	3,552	2,777	2,777	0.78
	9	Av. Pedro Cabral and Senador Lemos	34,380	34,380	26,876	26,876	0.78
		Subtotal	424,807	346,889	337,923	277,012	0.80
Bus terminal (8) and Bus Stops				47,821		38,102	0.80
Road Project	1	Av.Independencia on suburban segment		114,145		93,832	0.82
	2	Av.Independencia on central accessing segment		108,102		87,090	0.81
	3	Av. 1ro de Dezembro/ Mario Covas		150,208		120,311	0.80
	4	Rua Yamada		94,699		75,680	0.80
	5	Rua da Marinha		40,750		32,452	0.80
		Subtotal		507,904		409,365	0.81
Grand Total (including Extra Work)				980,533		785,391	0.80

Table 20.2-2 shows the annual investment amount during 2004 – 2012, which was calculated based on the same assumptions as the implementation program stated in Chapter 18.

The cost of the trunk bus system includes investment for extra work such as relocation of cycling roads and improvement of pedestrian decks. However, this extra work does not methodologically contribute to the economic benefits estimated in this analysis, so the cost flow excluding the extra works was used for the evaluation of the trunk bus system.

Table 20.2-2 Annual Investment Cost in Terms of Economic Cost

(R$ 1000)

Year	Trunk Bus System				Road	
	Financial Cost		Economic Cost		Financial Cost	Economic Cost
	Including Extra Work	Excluding Extra Work	Including Extra Work	Excluding Extra Work		
2004	70,780	55,288	59,812	47,473	34,913	32,889
2005	73,051	57,560	61,794	49,456	40,740	38,212
2006	245,497	198,562	189,925	153,691	101,883	81,144
2007	33,389	33,389	25,688	25,688	9,509	8,593
2008	16,274	16,274	12,666	12,666	75,579	58,447
2009	22,456	22,456	17,315	17,315	88,218	67,954
2010	11,182	11,182	8,825	8,825	76,105	59,351
2011	0	0	0	0	30,667	23,614
2012	0	0	0	0	50,289	39,162
Total	472,629	394,710	376,026	315,114	507,904	409,365

20.2.3. VEHICLE OPERATING COST AND TRAVEL TIME COST

(1) General

Savings in vehicle operating cost (VOC) is one of the main sources of economic benefit. The operating cost per unit distance is estimated by type of vehicle, such as passenger car, taxi, light truck, heavy truck, bus, large bus and articulated bus. The last one does not now exist in Belem but was added for the trunk bus system project. Extra-large trucks like tractor-trailers are not dominant in the urban area in Belem and were omitted.

VOC is composed of the following components:

(a) Fuel cost
(b) Oil cost
(c) Tire cost
(d) Repair cost
(e) Depreciation cost
(f) Capital opportunity cost
(g) Crew and overhead cost

In the Belem Municipality, CTBel (Belem Transport Company) has been periodically updating operating cost data of buses in order to revise bus fares. The estimates of the bus operating data in this study depend much on the basic information and assumptions of CTBels data.

In an urban area, unit VOCs are much affected by operating speed. Therefore, unit VOC of each component from (a) to (e) is expressed as a function of operating (travel) speed. A part of item (e) and the others (items (f) and (g)) are expressed in cost per travel time. The former group ((a) to (e)) is referred to as "VOC subject to travel distance" and the latter, "VOC subject to travel time".

Unit costs of each item are estimated at market price and are then converted into economic cost. VOC varies also by road surface conditions. However, unit VOCs were investigated only for paved roads because the roads examined in this study are mostly in the urban area and paved.

(2) Characteristics of Representative Vehicles

Although there are many vehicles of different makes and models actually running in Belem and a unit VOC varies by makes/models and also changes by vehicle age, several popular models are selected as representative ones and their VOCs are studied and aggregated by taking average.

Table 20.2-3 shows selected vehicles as representative ones and their average price. Their average prices and characteristics such as tire type, fuel type, operating distance and hours are shown in Table 20.2-4.

Table 20.2-3 Representative vehicles and Price

Vehicle Type	Size	Make	Model	Fuel	Price		Compo-sition(%)	Average Price	
					W/ Tax	W/o Tax		W/ Tax	W/o Tax
Car	Small	VW	Gol Special	Gasoline	15,740	11,085	73.7	15,593	10,853
		VW	Gol City	Methanol	16,630	11,711	12.6		
	Medium	VW	Kombi	Gasoline	25,990	16,554	6.9		
		VW	Kombi	Methanol	25,990	16,554	0.4		
Taxi	Small	VW	Gol City	Gasoline	16,630	11,711	93.0	16,630	11,711
		VW	Gol	Methanol	16,630	11,711	7.0		
Truck	Small	GM	Chevrolet	Gasoline	19,000	16,239	1.5	48,585	39,196
		GM	Chevrolet	Methanol	19,000	16,239	0.1		
	Medium	M. BENZ	Sprinter312D	Diesel	49,060	39,565	98.4		
Bus	Large	M. BENZ	OF1620	Diesel	129,750	115,848	100.0	129,750	115,848
	Articulated	Volvo/Marcopolo		Diesel	470,000	419,643	100.0	470,000	419,643

Note: W/ Tax and W/o Tax are "With" and "Without" Tax, respectively.

Table 20.2-4 General Characteristics of Representative Vehicles

	Vehicle Type / Vehicle Characteristics	Car	Taxi	Truck	Large Bus (100 pax.)	Articula-ted Bus (200pax.)
1	Price(Real) (1) Financial (2) Economic	 15,593 10,853	 16,630 11,711	 48,585 39,196	 129,750 115,848	 470,000 419,643
2	No. of Tires	4	4	6	6	10
3	Fuel Type	Gasoline Ethanol	Gasoline Ethanol	Diesel	Diesel	Diesel
4	Annual Operation (Km)	24,000	60,000	48,000	75,000	90,000
5	Average Speed (Km/Hour)	30	25	30	25	30
6	Annual using hours(Hours)	800	2,400	1,600	3,000	3,000

The economic costs are their market price less taxes. Taxes imposed on vehicles are as shown in Table 20.2-5. If a small car is purchased for use as a taxi-cab, IPI and ICMS are exempted, with a limit of one car per person. IPVA is collected annually on the residual value of a vehicle, while IPI and ICMS are levied once at a purchase of a vehicle.

Detailed tables for the VOC estimation are presented in Tables E-2 to E-16 in Appendix-E.

Table 20.2-5 Vehicle-related Tax in Belem

Vehicle Type		IPI	ICMS	IPVA
Car	Large Car	45%	12%	2.5%
	Medium Car	40%	12%	2.5%
	Small Car	30%	12%	2.5%
Bus	Bus	0%	12%	1.0%
	Large Bus	0%	12%	1.0%
	Articulated Bus	0%	12%	1.0%
Truck	Small Truck	5%	12%	1.0%
	Medium Truck	12%	12%	1.0%
	Large Truck	12%	12%	1.0%

IPI: Industrial Products Tax (Federal Government Tax)
ICMS: Tax on Circulation and Service (State Tax)
IPVA: Vehicle Ownership Tax (State Tax)

(3) Fuel and Lubricant Cost

In Belem, four types of fuel are used for vehicles: regular gasoline (R$2.10/liter), premium gasoline (R$2.14/liter), ethanol alcohol (R$1.61/liter) and diesel oil (R$1.41/liter). The retail prices are different by fuel station. The above prices are the averages surveyed at 46 stations. ICMS tax of 26% is imposed on each fuel except diesel, for which it is 18%.

The fuel consumption rate of a vehicle varies by its running speed. The most economical speed is 45 to 50 km/hr for a passenger car, and 50 to 60 km/hr for medium and large vehicles.

The retail price of lubricant oil is R$4.20/liter and after deducting tax, the economic cost is R$3.44/liter. According to general experimental data, the higher the travel speed, the lower the lubricant oil consumption.

(4) Tire Cost

The average market price of a set of tires is R$520 – 560 for a car and R$6300 – 1135 for a large vehicle. They include taxes at about 38% of the market prices. Although some vehicles use re-treaded tire, they are neglected here because the market share is not significant and the life of a re-tread tires is shorter than a brand new tire even if its price is lower, so there is no big difference in economic price per kilometer between the two.

Under the condition of average speed of 35 miles/hr (56 km/hr) on paved roads, average tire life can be assumed to be 45,000 km for a passenger car and 50,000 km for a heavy vehicle. Thus, tire consumption rates per 1,000 km are 8.9% and 12.0%, respectively. The consumption rate becomes larger when average running speed rises. This is according to an IBRD report ("Quantification of road user savings", IBRD Occasional Paper No.2, 1966).

(5) Repair Cost

Calculating annual maintenance cost based on CTBel's bus and taxi operating data, the rate of annual maintenance cost to the vehicle price (excluding tire cost) is estimated to be 4.2% for a passenger car and small truck, and 7.4% for other commercial vehicles with larger annual running distance.

According to the same IBRD report referred to in the tire cost estimation, the relationship between maintenance cost and running speed shows that maintenance cost becomes lowest at a speed of around 50 km/hr.

(6) Depreciation Cost

Depreciable amount is defined as the vehicle economic cost (without tire cost) less salvage cost after use during vehicle life. In Belem, where the market for secondhand vehicles and spare parts is well developed, the salvage value rate should be assumed at a rather high rate, specifically, 25% for a passenger car, 10% for a taxi, 15% for a small truck and 20% for buses.

Vehicles are devalued through their use in proportion to running kilometers, while their value will decrease as they become old, even without use. Particularly, passenger cars lose value rapidly as time passes. Therefore, the proportion of depreciation subject to use and depreciation subject to time may be assumed as follows: 50:50 for passenger car and 70:30 for others.

Depreciation subject to use is further subdivided into two parts. It is assumed that one third of this cost depends on the driven distance and two thirds is affected by running speed, in the same way as maintenance cost.

Time-related depreciation in the table presents daily depreciation cost which is the depreciable amount divided by number of days during the life period. This cost is independent from driven distance and from running speed. Therefore, this cost shall be calculated separately based on the number of vehicles in the region and added to the other costs which are affected by running speed. The same can be said for the capital opportunity cost, crew cost and overhead cost.

(7) Capital Opportunity Cost (Interest)

This cost is not affected by use but accrues only as time passes and is determined by vehicle price, life period, salvage value rate and interest rate, using the following formula:

$$C = P\,(1 - r)\,F - P / n + i\,r\,P$$

$$F = i\,(1 + i)^n / (\,(1 + i)^n - 1)$$

Where, C : Capital opportunity cost (Interest)

P : Economic cost of vehicle

F : Capital recovery factor

r : Salvage value rate

i : Interest rate

n : Durability (Vehicle life)

Interest rate is assumed at 12% which is the same rate as the discount rate used when calculating evaluation indices. Total capital opportunity cost in the study area is the product of this daily cost and total number of vehicles existing in the area. Therefore, in a with-and-without comparison for project evaluation, this cost will be cancelled if both cases have the same number of vehicles.

(8) Crew Cost and Overhead Cost

Also, this cost is not affected by driven distance but is proportional to time. According to CTBel's data, the average annual wage of a bus driver is about R$15,000 (13 times the monthly salary) while that of a taxi drivers is lower than this amount by approximately 45%. The average wage of a truck driver is the same as a bus driver's.

In Belem, most taxis and trucks are owned by individuals, not by an enterprise. Under these circumstances, therefore, not much overhead cost is needed. Bus owner's profit is not regarded as economic cost, and the overhead cost of the truck transport business is about 30% of crew cost.

(9) Aggregate VOC

Aggregate unit VOCs are summarized as shown in Table 20.2-6 both in terms of financial and economic prices. Figure 20.2-2 compares the unit VOCs by types of vehicle, at the speed of 30 km per hour. The cost of an articulated bus is 7 times of a car and 1.9 times that of a large bus. At this speed, the VOC subject to time is rather small, 25 to 30% of the total. The relationship between VOC and travel speed is illustrated in Figure 20.2-3. This relation was used as a table function to estimate economic benefits.

To calculate total VOC in a network, first, the running speed of each link must be obtained from the traffic assignment result; second, total distance-related cost is calculated by summing up the cost in each link. Finally, time-related cost calculated separately using the total vehicle-time is added to the distance-related cost.

Table 20.2-6 Aggregate VOC in Belem, 2003

(1) VOC subject to Use (R$/1000Km)

	Speed (Km/hour)	Car	Taxi	Truck	Large Bus (100 pax.)	Articulated Bus (200pax.)
Financial Cost (R$/1000km)	5	564.4	837.6	2154.9	1666.7	2692.4
	10	387.1	563.1	1457.4	1199.3	2097.7
	20	291.1	417.3	1100.8	937.2	1703.4
	30	258.1	367.2	865.6	869.2	1580.0
	40	240.8	341.4	758.8	821.5	1483.8
	50	235.6	334.3	723.3	849.7	1482.0
	60	241.2	343.5	710.9	922.5	1553.3
	70	252.4	361.1	734.7	1023.4	1669.5
	80	272.4	390.1	805.4	1160.3	1871.2
	90	300.2	430.6	905.0	1293.4	2086.1
Economic Cost (R$/1000km)	5	417.8	619.2	1750.3	1384.0	2271.6
	10	285.6	415.4	1179.1	997.9	1776.7
	20	214.1	307.3	886.1	778.0	1440.2
	30	189.5	270.1	691.8	718.3	1329.5
	40	176.5	250.8	601.2	674.1	1239.4
	50	172.5	245.4	568.1	691.6	1225.6
	60	176.6	252.2	555.7	748.3	1277.8
	70	184.8	265.0	573.3	829.0	1368.9
	80	199.3	286.2	626.3	937.8	1529.6
	90	219.5	315.6	700.7	1042.0	1698.8

(2) VOC subject to Time (R$/Hour)

	Car	Taxi	Truck	Bus (60 pax.)	Articulated Bus (100 pax.)
Financial Cost					
Depreciation	0.707	0.517	0.666	1.411	5.242
Capital Opportunity Cost	1.413	0.442	1.802	2.839	10.090
Crew and Overhead Cost	0.000	3.128	9.384	5.980	5.980
Total	2.120	4.087	11.852	10.229	21.312
Economic Cost					
Depreciation	0.494	0.365	0.558	1.279	4.716
Capital Opportunity Cost	0.987	0.313	1.509	2.575	9.078
Crew and Overhead Cost	0.000	2.346	7.038	4.485	4.485
Total	1.481	3.024	9.105	8.339	18.279

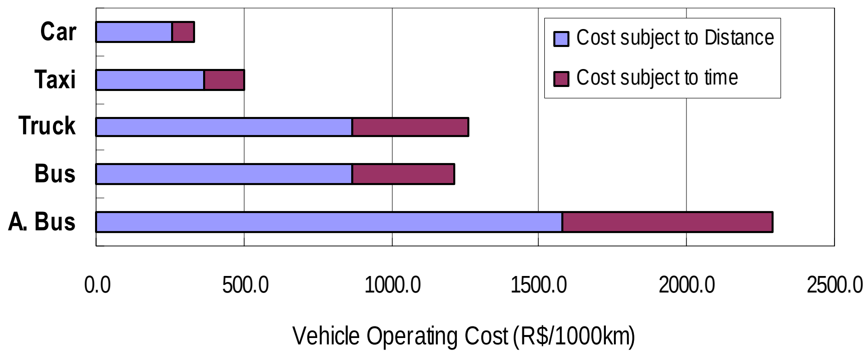


Figure 20.2-2 Vehicle Operating Cost by Type of Vehicle

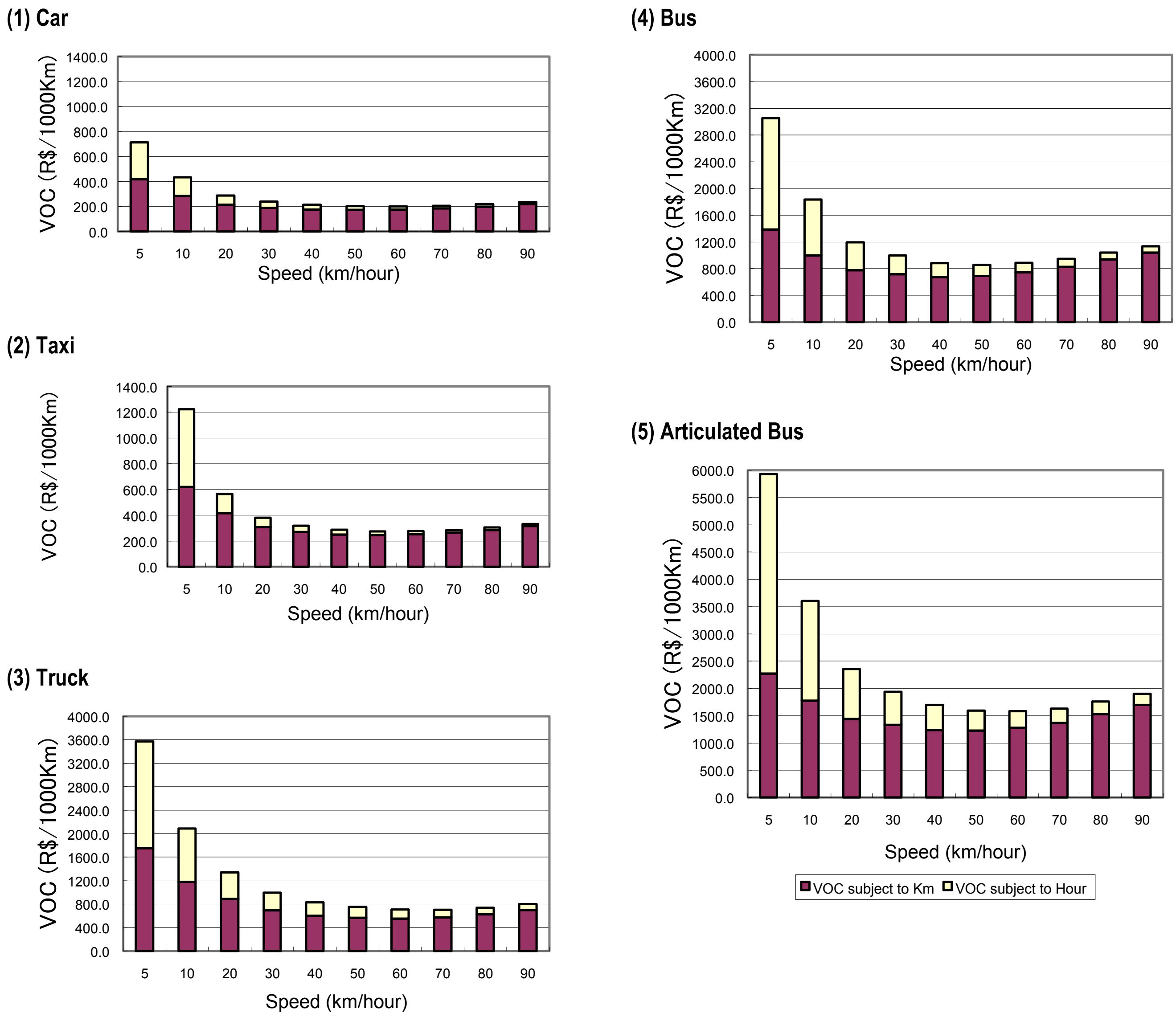


Figure 20.2-3 VOC by Travel Speed

20.2.4. Travel Time Value

The travel time of car users and bus passengers is converted to money terms using unit time value. Their time values are estimated based on their income level, which reflects their productivity. According to a home interview survey data on person trips conducted in 2000 by the EVPDTU Study, monthly household income is distributed as shown in Figure 20.2-4. The average was R$822 a month. There was a big gap between the average of a car owning family (R$1,960 / month) and a non car-owning family (R$460 / month).

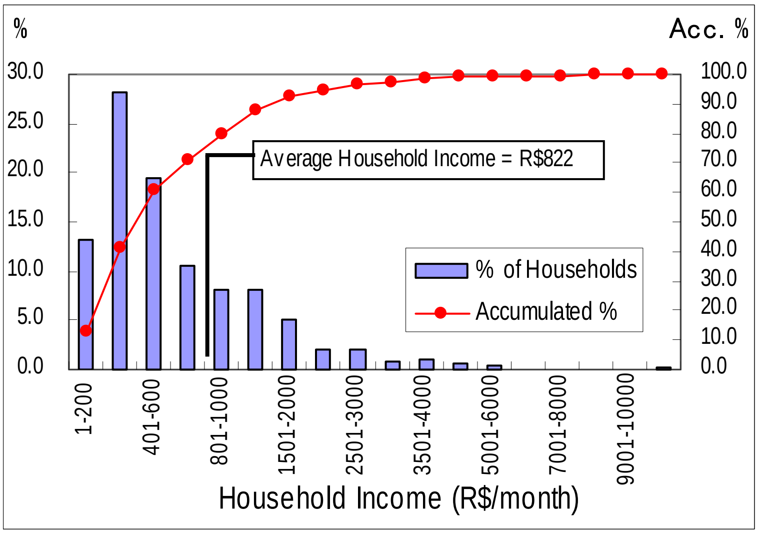


Figure 20.2-4 Distribution of Monthly Household Income in Belem

Assuming monthly working hours of 150 hours, the value of one hour at work is estimated at R$3.0 for a non-car owner (i.e., public transport passenger) and R$13.0 for a car owner (i.e., car user) in 2003. (Table 20.2-7)

All trips with a "business" purpose are regarded as productive activities and then time spent for a "business" trips is given the said value. The share of "business" trips is 7.5%. "To work" trips (with a share of 14.6%) and "to home" trips from work are assumed to have half of the time value, while other trips have no time value.

Table 20.2-7 Time Value of Passengers in Belem, 2002

(R$/Hour)

	2000	2002	2007	2010	2015	2020
Working Hour						
Car Owner	9.8	13.0	13.7	14.3	15.1	16.1
Non-car Owner	2.3	3.0	3.2	3.4	3.6	3.8
Travel Time						
Car Owner	3.8	5.0	5.3	5.5	5.8	6.2
Non-car Owner	0.9	1.2	1.2	1.3	1.4	1.5
By Transportation Mode						
Car	8.2	10.9	11.6	12.0	12.8	13.5
Truck	7.7	10.2	10.8	11.2	11.9	12.6
Bus	26.9	35.7	37.8	39.2	41.6	44.2
Articulated Bus	88.6	117.3	124.5	129.0	137.0	145.4
Feeder Bus	26.9	35.7	37.8	39.2	41.6	44.2

Time value will change by year. The higher people's productivity rises, the larger the time value becomes. Then, it may be reasonable to assume the time value will rise at the same rate as GRDP per capita growth. In this study, GRDP per capita is assumed to grow at 1.2% p.a., and accordingly, time values will rise to 1.24 times those in 2002.

Total TTC is estimated by multiplying these unit time values by aggregate passenger-hours by a mode calculated from assigned traffic in a network.

20.2.5. RESULTS OF ECONOMIC EVALUATION

(1) Entire Projects

1) Economic Benefit

First, all the study projects were evaluated as one set, assuming that they were implemented as scheduled. The aggregate amount of the vehicle operating cost (VOC) and the travel time cost (TTC) means economic expenditure to support people's social and economic activity in a city. Figure 20.2-5 illustrates the future increase of the amount in Belem. The red colored portion on each bar is the difference between the "with" and "without" projects, that is, the benefit of the projects.

Without the project, total cost will increase from R$1,620 million in 2007 to R$2,557 million in 2012. If the study projects are implemented, the annual cost in 2012 will be reduced to R$2,272 million. Then, R$285 is the benefit to accrue in year 2012. In the same way, the first year benefit is R$97 million in 2007 and it is R$101 million in 2020.

.

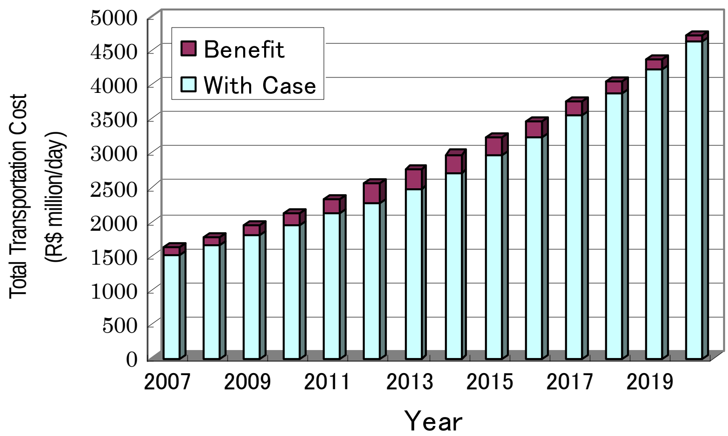


Figure 20.2-5 Daily Transport Cost and Benefit of Trunk Bus System

Table 20.2-8 shows the economic benefit by source. In 2007, about 20% of the benefit is generated by savings in VOC and 80% by savings in TTC. The VOC savings will expand its share in 2012 due to the opening of the trunk busway on the western section of Av. Independencia and completion of other road projects. Comparing the benefits to the public and the private mode, about one third of the benefits will accrue to the public mode and the share will fall to 18% in 2012, also due to the completion of road projects. In the long term, however, the share of the public mode will become dominant because the road projects become less effective against an overwhelming demand increase.

Table 20.2-9 shows the change in average travel speed by mode. The average speed of cars, trucks and conventional buses will be improved by 4 – 6 km/hour by the projects. However, this effect will not last until 2020 due to a significant increase of traffic. On the other hand, articulated buses and feeder buses will maintain high speed. This is because articulated buses are provided with segregated lanes, and feeder buses are operated only in the suburban areas.

Table 20.2-8 Economic Benefit of Trunk Bus System Project by Source

(R$ million)

Case	Cost Item	2007			2012			2020		
		Public Mode	Private Mode	Total	Public Mode	Private Mode	Total	Public Mode	Private Mode	Total
Without Case	VOC	161.9	657.5	819.4	189.7	1000.2	1189.9	198.4	1784.6	1983.0
	TTC	176.2	624.1	800.3	230.4	1137.1	1367.6	282.6	2448.5	2731.1
	Total	338.0	1281.7	1619.7	420.1	2137.3	2557.5	481.0	4233.1	4714.1
With Case	VOC	164.7	633.5	798.2	192.7	925.0	1117.7	198.9	1774.2	1973.0
	TTC	138.2	586.1	724.3	175.8	978.6	1154.3	227.7	2411.5	2639.2
	Total	302.9	1219.5	1522.4	368.4	1903.6	2272.0	426.6	4185.7	4612.3
Benefit	VOC	-2.8	24.1	21.3	-3.0	75.2	72.2	-0.5	10.4	9.9
	TTC	37.9	38.1	76.0	54.7	158.5	213.2	54.8	37.0	91.9
	Total	35.1	62.1	97.3	51.7	233.7	285.4	54.3	47.4	101.8

Table 20.2-9 Average Speed Change by Trunk Bus System Project

(Km/Hour)

Vehicle Type	2000	2007		2012		2020	
		With	Without	With	Without	With	Without
Car	32.7	26.9	23.6	20.5	14.9	8.7	8.2
Truck	50.0	36.8	32.4	29.9	23.5	13.3	13.1
Conventional Bus	31.0	25.5	21.5	21.8	15.5	10.3	8.8
Articulated Bus	-	32.6	-	32.8	-	29.8	-
Feeder Bus	-	25.0	-	23.2	-	21.5	-
Total	35.7	28.3	24.5	22.0	16.0	9.5	8.7

2) Cash Flow and Evaluation Indicators

As in the cost-benefit cash flow of the project shown in Table 20.2-10, the economic viability of the project is very high showing 28.0 % of IRR and R$ 495 million of NPV. The B/C ratio is almost 2.0. In Brazil, the economic discount rate of 12% is generally used. Then, these figures indicate the study projects are highly feasible from the economic viewpoint.

In the cash flow, maintenance cost assumes overlaying or 50% of the bus-lane surface in the first decade and 100% in the next decade. This assumption was applied to all the cases.

3) Sensitivity Analysis

The sensitivity of the E-IRR was examined by changing the cost and the benefit. As shown in Table 20.2-11, the E-IRR is quite stable. The E-IRR falls below 12% only when the cost becomes over 1.8 times the original estimate or the benefit falls to less than 53% of the estimate. The shaded area in the table shows an area where the project will be unfeasible. If the cost overruns by 20% and at the same time the benefit becomes less than 60% of the original estimate, there is a risk of E-IRR below 12%. However, such a situation would hardly happen.

Table 20.2-10 Economic Cash Flow of All Study Projects

Year	Investment	Mainte-	Benefit	Net Cash
2004	77.5			-77.5
2005	84.8			-84.8
2006	202.5			-202.5
2007	34.3	1.5	97.3	61.5
2008	71.1	1.5	125.9	53.3
2009	85.3	1.5	163.1	76.3
2010	68.2	1.5	211.2	141.5
2011	23.6	1.5	280.9	255.7
2012	39.2	3.5	285.4	242.8
2013		3.5	250.9	247.4
2014		3.5	220.6	217.1
2015		3.5	193.9	190.4
2016		3.5	170.4	166.9
2017		3.5	149.8	146.3
2018		3.5	131.7	128.2
2019		3.5	115.8	112.3
2020		3.5	101.8	98.3
2021		3.5	89.5	86.0
2022		7.0	78.7	71.7
2023		7.0	69.1	62.1
2024		7.0	60.8	53.8
2025		7.0	53.4	46.4
2026	-1.2	7.0	47.0	41.2
2027		5.5	41.3	35.8
2028		5.5	36.3	30.8
2029		5.5	31.9	26.4
2030		5.5	28.0	22.6
2031		5.5	24.7	19.2

IRR (%)	28.0
NPV (R$ million)	495.3
B/C	1.97

Table 20.2-11 Sensitivity Analysis of All Study Projects

(E-IRR:%)

Benefit	Cost	Cost up					
		Base Case	20% up	40% up	60% up	80% up	100% up
Benefit down	Base Case	28.0	23.2	19.4	16.4	13.8	11.7
	20% down	22.2	17.8	14.4	11.7	9.4	7.4
	40% down	15.5	11.7	8.7	6.3	4.2	2.4
	60% down	7.4	4.2	1.6	-	-	-

(2) Trunk Bus System Project

The trunk bus system project was evaluated separately from the road project. Here, it was assumed that only the trunk bus project is implemented as scheduled and no road projects are built in both cases of "with" and "without" the trunk bus system. This is to exclude any influence of the road projects.

1) Sources of Economic Benefit

The trunk bus system consists of three components: construction of exclusive bus way/lane, rearrangement of bus routes and introduction of large buses. According to the result of simulations applying each component one by one for the year 2012, the contribution of each component was analyzed as shown in Figure 20.2-6.

First, the economic benefit of the trunk bus system will be R$62 million if all the components are implemented as one set. Of the benefit, R$49 million will go to the public transport users and R$13 million to users of the private mode (car and truck).

If all the buses operated on the 41 routes competitive with the trunk bus route are replaced by articulated buses, but while providing neither exclusive lanes nor bus rerouting, the economic benefit will be R$69, million of which R$19 million is to the public mode and R$50 million to the private mode. It is noted that the total benefit of this case is larger than that of the entire trunk bus system mentioned above.

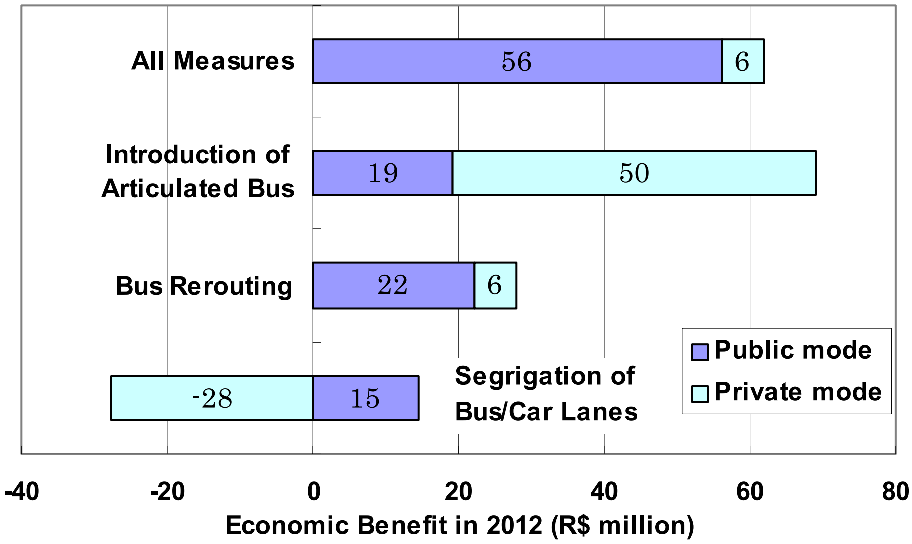


Figure 20.2-6 Sources of Economic Benefit of Trunk Bus System in Year 2012

If bus routes are rearranged properly, it will be more beneficial to bus passengers than the articulated bus introduction. In this case, however, the benefit to the private mode is small.

Lastly, if the public and the private modes are segregated along the planned trunk bus route, the public mode will get R$15 million of benefit but on the other hand, the private mode will lose R$28 million. This means the planned road does not have enough capacity to segregate the public and private modes without proper combination with other measures.

As the benefit of each component is not mutually independent, the benefit of a combination of components does not necessarily tally with the sum of the individual benefit of each component. The benefit of the entire trunk bus system is R$72 million in 2012 and the sum of each component's benefit is R$84 million. Very roughly speaking, the component of articulated buses contributes 70% to the total benefits and the bus-rerouting component contributes 30%. The last component of bus segregation has will shift some of the benefit generated by the articulated bus component from the private mode to the public mode, by sacrificing about 13% of total benefit.

Modal segregation on a road section is a matter of capacity allocation among modes. Accordingly, a gain of a mode will sometimes cause a loss of the others as in a zero-sum game. Therefore, if a negative impact is forecast on some mode, it is necessary to examine whether the impact is in the tolerable range to the mode concerned. In Belem's case, the private mode will suffer a loss by the exclusive bus lane. However, the loss will be recovered by other components and in the end, the entire trunk bus system will bring a benefit also to the private mode, as shown in Figure 20.2-6.

2) Evaluation Results and Sensitivity Analysis

The trunk bus system project was evaluated by applying the same method as for all study projects. The resultant benefits and evaluation indicators are as shown in Table 20.2-12. The main beneficiary is the public mode. The economic IRR is 17.0%, which assures the project's feasibility. (Detailed cash flow is shown in Table E-17 in Appendix-E.)

Table 20.2-12 Evaluation Results of Trunk Bus System Project

(1) Economic Benefit

(R$ million)

Year	Public	Private	Total
2007	32.3	8.5	40.8
2011	47.6	12.6	60.1
2012	49.0	13.0	62.0
2020	55.4	5.5	60.9

(2) Evaluation Indicators

IRR (%)	17.0
NPV (R$ million)	84.9
B/C	1.36

Table 20.2-13 shows the result of a sensitivity analysis, done by changing the cost and the benefit. The feasibility is rather sensitive to both factors. The IRR will fall below 12% if the cost becomes 1.37 times higher than the estimate or the benefit becomes 27% lower than the estimate. Then, it is important to monitor the cost and during the period of detailed design and construction and traffic volume before and after project implementation.

Table 20.2-13 Sensitivity Analysis of Cost and Benefit Change

(E-IRR:%)

Benefit	Cost	Cost up					
		Base Case	10% up	20% up	30% up	40% up	50% up
Benefit down	Base Case	17.0	15.4	14.0	12.7	11.6	10.6
	10% down	15.2	13.7	12.3	11.1	10.1	9.1
	20% down	13.3	11.9	10.6	9.5	8.5	7.5
	30% down	11.3	9.9	8.7	7.7	6.7	5.8

3) Economic Return by Trunk Bus Route

Figure 20.2-7 is to compare the economic benefit of each trunk bus route, which was estimated with the condition that there exists only one trunk bus route to be analyzed and there are no other routes or road projects.

Among the three routes, Av. Independencia will generate the largest benefit, followed by Av. Almirante Barroso & BR-316. Comparing these two, the benefit to the public mode is almost same but the benefit to the private mode by Av. Independencia is much larger than that by Av. Almirante Barroso and BR-316. This is because some buses will divert to the new route of Av. Independencia in the former case, while the existing road capacity is shared by the two modes without increase of road capacity in the latter case.

Assuming the benefit of the entire project at 100, the benefits by route are 90, 61 and 39 from the largest one. On the other hand, cost proportion is 36, 37 and 39 in the same order. (As the cost of Av. Almirante Barroso is counted twice, the total is not 100.) Then, Av. Independencia has apparently the highest economic efficiency followed by BR-316 and Rodovia Augusto Montenegro, in this order.

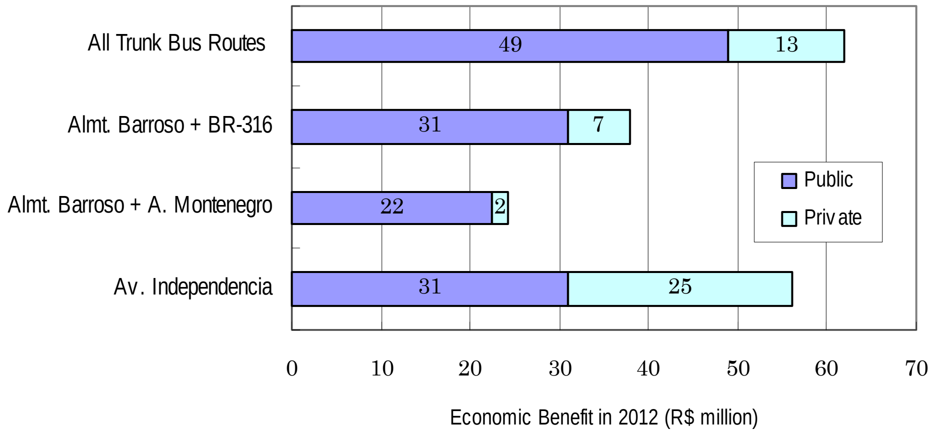


Figure 20.2-7 Economic Benefit by Trunk Bus Route in 2012

(3) Road Project

1) Economic Benefit and Evaluation Indicators

The entire road project was evaluated as a set and the results were as shown in Table 20.2-14. An extremely high IRR at 41% indicates implicitly that future traffic condition would become such worse with no road project. Further evidence of this is a small benefit in 2020, which means that the road network cannot deal with the future demand even with the study road projects.

Table 20.2-14 Evaluation Results of Road Projects

(1) Economic Benefit

(R$ million)

Year	Public	Private	Total
2007	6.6	58.0	64.6
2011	9.8	213.7	223.5
2012	8.5	224.9	233.4
2020	2.8	45.7	48.4

(2) Evaluation Indicators

IRR (%)	41.0
NPV (R$ million)	429.2
B/C	2.53

2) Sensitivity Analysis

Table 20.2-15 shows the result of a sensitivity analysis of the road project. The IRR of the project is very high and the feasibility is quite stable against both the cost and the benefit. The IRR will be below 12% if the cost becomes 2.5 times higher than the estimate or the benefit becomes 60% lower than the estimate.

Table 20.2-15 Sensitivity Analysis of Road Project

(E-IRR:%)

Benefit	Cost	Base Case	20% up	40% up	60% up	80% up	100% up	120% up	140% up	160% up
			Cost up							
Benefit down	Base Case	41.0	34.5	29.2	25.0	21.4	18.3	15.7	13.3	11.3
	20% down	33.0	27.0	22.2	18.3	15.1	12.3	9.8	7.7	5.8
	40% down	23.7	18.3	14.1	10.6	7.7	5.2	2.9	0.9	-
	60% down	12.3	7.7	4.0	0.9	-	-	-	-	-
	70% down	5.2	0.9	-	-	-	-	-	-	-

3) Evaluation of Individual Road Project

The study road project consists of four road projects. They were evaluated individually, by analyzing "with" and "without" cases one by one. The results are shown in Table 20.2-16. Av. Primeiro de Dezembro implies the highest economic return of 45%, followed by Av. Independencia of 43%, Rua da Marinha of 38% and lastly, Rua Yamada of 18%. The top two projects are large in terms of investment scale, compared with the other two. Accordingly, NPVs are also large. All the road projects are judged economically to be good and their early implementation is highly recommended.

Table 20.2-16 Economic Evaluation of Individual Road Project

Project	Extension (km)	Cost (R$ million)		Economic Evaluation		
		Financial (R$ million)	Economic (R$ million)	E-IRR (%)	NPV (R$ million)	B/C -
Independencia	19.6	222.2	180.9	42.8	247.8	2.75
Av.Primeiro de Dezembro	10.1	150.2	120.3	45.2	330.7	5.12
Rua Yamada	10.0	94.7	75.7	18.0	37.6	1.80
Rua da Marinha	4.6	40.8	32.5	37.9	49.2	4.05
Entire Road Projects	44.2	507.9	409.4	41.0	429.2	2.53

(4) Investigation on Economic Evaluation Results

The following is notes on important information, found in the course of the economic analysis or deduced from the results of the evaluation.

1) Project Life

As shown in this chapter, the trunk bus system and road projects studied in the study will improve transportation conditions in Belem and their economic return will be significant. It should be noted, however, the effects of travel speed improvement and economic return will be canceled out by the future traffic increase within 15 to 20 years.

Car traffic is forecast to grow 3.5 times by 2020, while public transport demand will increase only 1.3 times. Current capacity of the road network is absolutely insufficient to cope with such an increase of car traffic. Besides the study projects, comprehensive measures should be taken, covering not road improvement but a variety of measures such as demand management, introduction of mass-transit and decentralization of urban functions. In this sense, the trunk bus is a transitional measure to a mass-transit era and its life is possibly 15 – 20 years.

2) Creation of Job Opportunity

The Belem Metropolitan area is now suffering from an unemployment problem with a 14% unemployment rate. This means more than 100,000 people are looking for a job. Under such a situation, the study projects are significant also in job creation in the course of implementation.

Total project cost of the study is estimated at R$747 million, if deducting compensation cost and contingency. Out of the total, R$497 million is the direct cost. Assuming that 10% of direct cost and 5% of other costs (indirect cost, engineering and administration cost) are personnel cost, and that 30% of personnel cost in the direct cost and 20% of personnel cost in the other costs are paid to the unskilled, then total wage payments will reach 62,300 man-months, of which 27,900 man-months are for the unskilled. Thus, the study projects are expected to contribute to mitigation of the unemployment issue. (Here, the average monthly salary is assumed at R$480 for the unskilled and R$1,000 for the skilled.)

3) Savings in Fuel Consumption

Although saving of fuel consumption is only a minor part of the entire economic benefit, it may be a key issue to car users and also important for environmental conservation. In 2012, the study projects will reduce the total daily running distance by 274,000 car-km, 2.3% of the distance in the "without" case. By this, R$23.8 million will be saved in a year. In addition, the projects will improve running speed from 15 km/hour to 16 km/hour on average. This slightly improved speed will result in a saving of R$0.7 million. Thus, a total of R$24.5 million of fuel cost will be saved in a year. This is equivalent to more than 100,000 barrels of gasoline.

20.3. FINANCIAL ANALYSIS OF TRUNK BUS SYSTEM

20.3.1. STANDPOINT AND METHODOLOGY OF FINANCIAL ANALYSIS

(1) Standpoint and Scope of Analysis

The objective of this financial analysis is to examine the profitability of the trunk bus operation business in Belem. The business scope of the trunk bus operator has not been clearly defined yet. It may operate some conventional bus routes, too. It may not cover the operation of bus terminals. In this analysis, however, the business scope of the operator is limited for analytical purposes, to (1) trunk bus operation, (2) feeder bus operation and (3) terminal operation directly related to the trunk bus operation.

It is also possible that the trunk bus be operated by multiple entities such as a consortium of existing bus companies, instead of a single entity. Even in such a case, the analysis regards such multiple entities as one bus company. In case, for example, the third entity manages the trunk/feeder bus system and undertakes clearance of the bus fare revenue, the cost for such work should be made endogenous (i.e. regarded as an internal cost).

The analysis assumed that all the infrastructure and terminals for the trunk bus system should be prepared by public investment of Para State or the municipalities belonging to the Belem Metropolitan Area. Accordingly, the trunk bus operators need not bear any financial burden for investment in infrastructure and terminals.

(2) Overall method

The analysis was made in the framework shown in Figure 20.3-1. The main work is to prepare inputs to the financial model. The main external (exogenous) variables are investment, revenue and operation/maintenance cost. The model will create pro-forma financial statements and deduct indicators for evaluation.

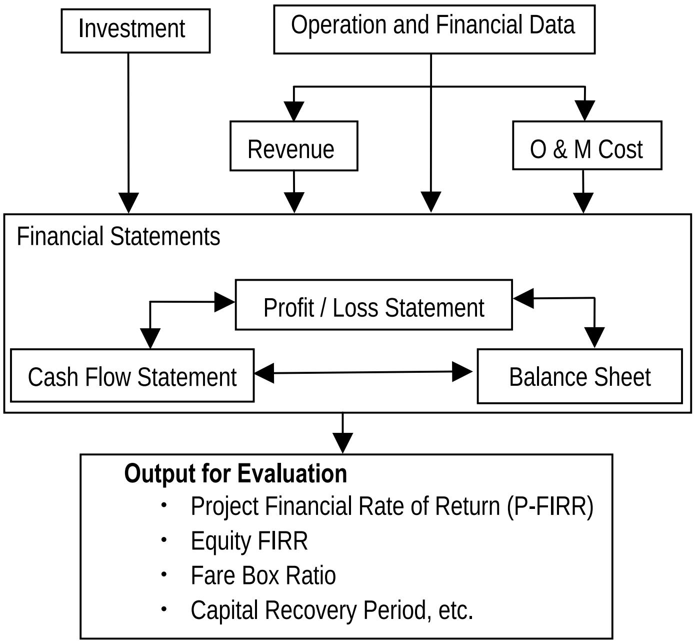


Figure 20.3-1 Framework of Financial Evaluation of Trunk Bus System

The model works out the financial statements in two ways: in real terms using constant price and in nominal terms using current price. The financial statements in real terms are mainly used for estimation of F-IRR and the nominal one is used for examination of the cash flow of the operating entity.

(3) Financial Model for Belem Trunk Bus System

A financial model was developed to simulate the financial conditions of the Belem Public Transportation Company after opening trunk bus operation. The model's structure is illustrated in Figure 20.3-2 and Figure 20.3-3. The main outputs of the model are three financial statements. Their main objectives are as follows:

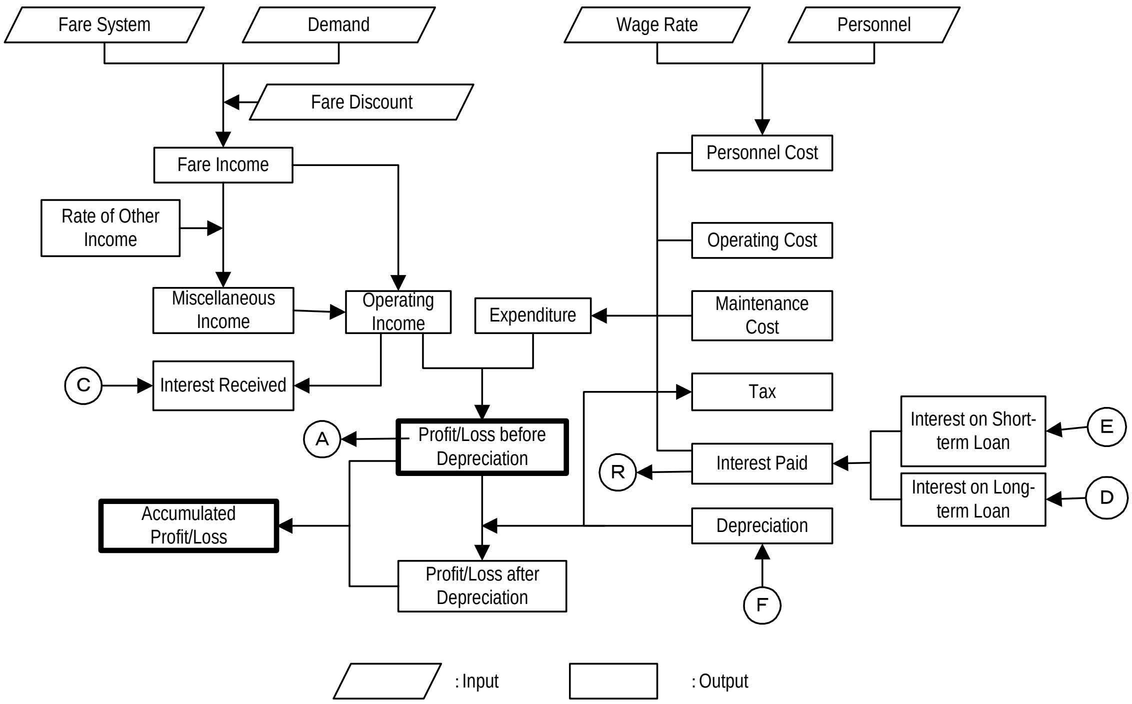
1) The profit/loss statement is for estimating the annual profit or loss by deducting expenses and taxes from revenue.

2) The cash flow statement is for estimating annual surplus or deficit by deducting cash outflow such as operating expenses, investment, interest paid, tax payment, and dividend from cash inflow such as capital, operating income, borrowing, and interest received. By this statement, annual demand for funds, as well as the profitability of a project, can be known.

3) The balance sheet is for assessing the financial stability and soundness of the company by comparing assets with liability and capital at the end (or at the beginning) of a fiscal year.

As the figure shows, these three statements are mutually related through input and output and then the calculation has to be done year-by-year. In general, the main purpose of financial analysis of a project is to clarify profitability and soundness in cash flow of the project. In the case of this project, the profitability analysis will be more important because no private funds will flow to any project without enough profitability.

(a) Profit/Loss



(b) Cash Flow

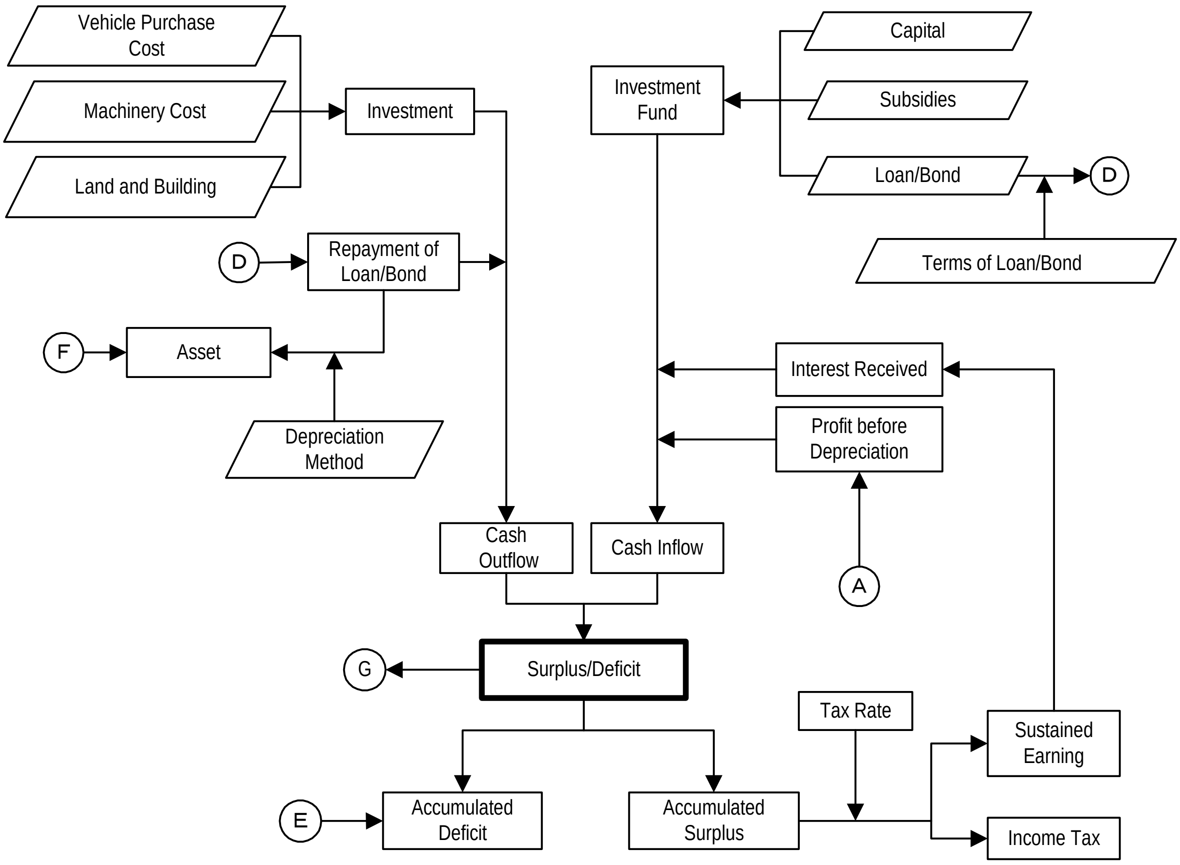


Figure 20.3-2 Structure of Financial Model

(c) Balance Sheet

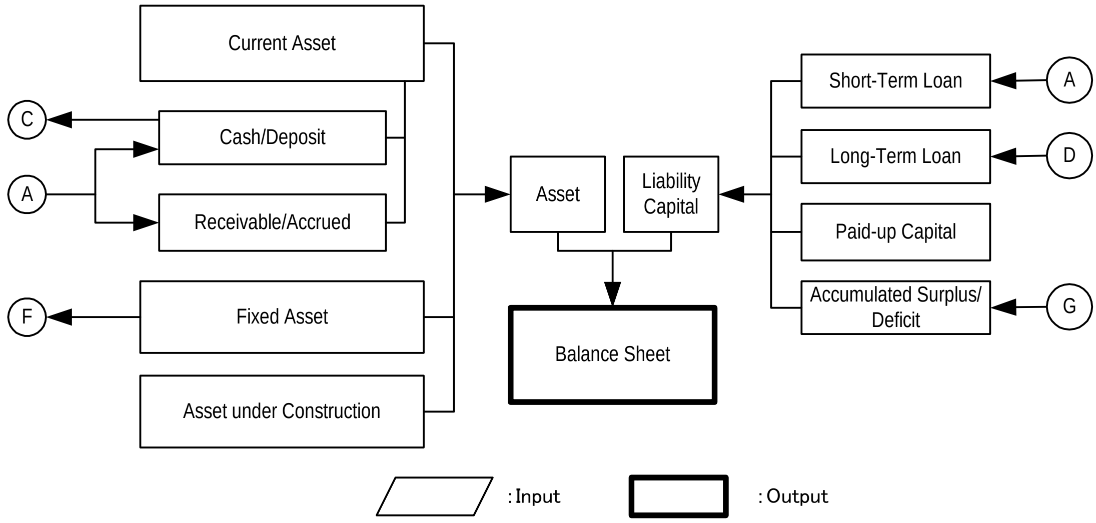


Figure 20.3-3 Structure of Financial Model (Cont'd)

20.3.2. MANAGEMENT AND OPERATION OF TRUNK BUS SYSTEM

(1) Organization and Operating Cost of Management Unit

Whether the trunk bus is operated by a single entity or by multiple entities, establishment of an organization for the trunk bus operation will be needed in any case. Functions of the organization are to control the daily operation of the trunk buses and feeder buses at terminals, to monitor daily performance of the system and clearance of the fare revenue if the bus is operated by multiple entities.

Figure 20.3-4 is an example of the trunk bus system management unit (TBSMU) to undertake such functions. The figures above each box show the number of staff members of the organization. The sample organization assumed a consortium of existing bus companies as the operators and then the accounting department is responsible for fare collection and re-distribution of revenue among bus operators following some rules.

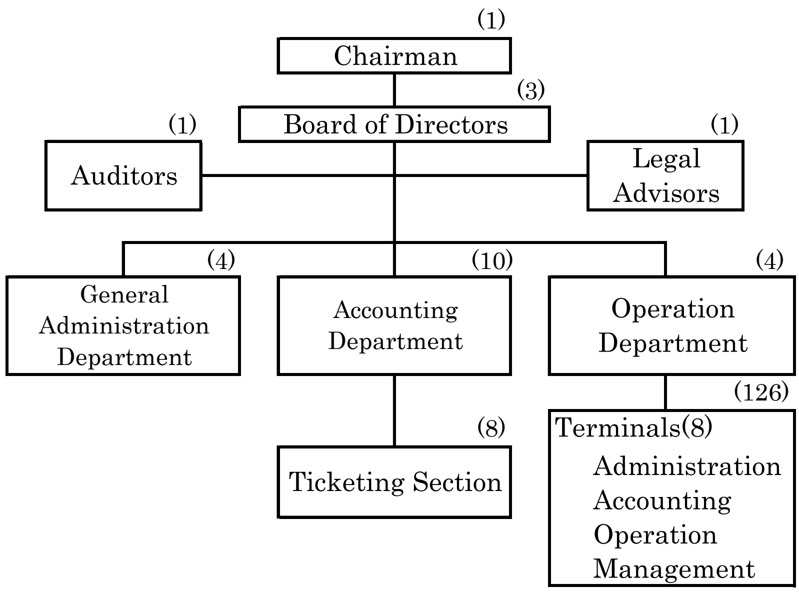


Figure 20.3-4 Organization of Trunk Bus System Management Unit

The operation department has a duty to control daily operation, to monitor demand and supply and to coordinate fleet assignment among bus operators. Under the department, there are eight terminal sections that employ dispatchers, inspectors and staff for maintenance of terminal facilities, in addition to the managerial personnel and staff for administration and accounting of each terminal. The total staff number is 156 persons.

Table 20.3-1 shows annual operating cost of the TBSMU. Total estimated cost is about R$2.8 million a year, which corresponds to 1.5 % to 1.6% of the annual fare revenue after 2012. Bus operators should evenly shoulder this amount as an additional overhead cost.

(2) Trunk Bus Operator

As stated before, there are two possibilities about "who will be the operator". One is the winner of the bidding for the new public transportation business. This is the case in which the Government puts the project up for bidding through a public tender. The other is the present bus operators. This is the case in which the Government carries out the project not as a new bus service, but as a readjustment or re-organization of bus routes. It has not been concluded yet which one will be the actual case.

Table 20.3-1 Operating Expense of Trunk Bus System Operating Unit

(1) Staffing and Personnel Cost (1000 R$/Year)

Department/Section		Function	Quantity	Monthly Salary	Total Annual Salary (R$1000)
1	Headquarter		**30**	**-**	**387.0**
	Managerial Personnel		4	1500	101.0
	General Administration Dept.	Daily administration works	4	700	47.0
	Accounting Department	Accounting and clearance	10	700	118.0
	Ticketing Section	4 persons x 2 shirts	8	550	74.0
	Operation Department	Management of terminals, Operation & Fleet plan	4	700	47.0
2	Terminals		**126**	**-**	**1292.0**
	Managerial Personnel	2 persons x 8 terminals	16	700	189.0
	General Administration Section	2 persons x 8 terminals	16	700	189.0
	Accounting Section	2 persons x 8 terminals	16	700	189.0
	Operation Section	4 persons x 2 shifts x 8 terminals x 120%	78	550	725.0
3	Total		**156**	**-**	**1679.0**

(2) Operating Cost (1000 R$/Year)

Cost Item			Quantity	Unit Cost	Total Cost
1	Headquarter			**-**	**604.5**
1.1	Personnel Cost			1679.0	387.0
1.2	Office Rent	750m^{2}x R$10/month x 12 months	1	24.0	24.0
1.3	Office Expense & Miscellaneous	50% of personnel cost			193.5
2	Terminals			**-**	**2211.2**
2.1	Personnel Cost				1292.0
2.2	Office Rent	R$1500/monthx12months x 8 terminals	8	18.0	144.0
2.3	Office Expense & Miscellaneous	30% of personnel cost			387.6
2.4	Maintenance Expense	30% of personnel cost			387.6
3	Total			**-**	**2815.7**

In this analysis, the latter case is assumed. The bus fleet now operated on the 41 routes to be abolished after the trunk bus service opens is recommended for use as trunk buses during the transitional period, in order to economize the project and also to make a smooth switchover from the current system to the trunk bus system.

This is just an assumption for the purpose of analysis. However, even if the other case happens, the results and conclusion will not be affected much, as long as the operator will invest the same amount as the assumed case.

20.3.3. INVESTMENT

In the early stage of the trunk bus operation, a part of the existing bus fleet will be used for the trunk bus system. The fleet size is 300 units for trunk bus service and 50 units for feeder bus service. These used buses will be replaced after 10 years usage, with new articulated buses.

New buses will be purchased with the cumulative retained profit or a loan. Therefore, the used buses are only an initial investment in this project from the operators. Then, the value of the used buses was assessed and the amount was regarded as capital in kind.

In Brazil, the buses are legally depreciated in seven years with 15% residual value. (The residual value of an articulated bus is 10%.) However, the market price of a used bus is much higher than the book value of the bus. In this analysis, therefore, 10 years depreciation with 20% residual value was assumed to appraise the value of used buses. Figure 20.3-5 illustrates the legal depreciation and the assessed value used in this analysis.

Assuming a flat distribution of bus age on these 350 units, the appraised value was R$21.8 million as shown in Table 20.3-2. This amount was regarded as the own capital of the operators, paid up in 2006.

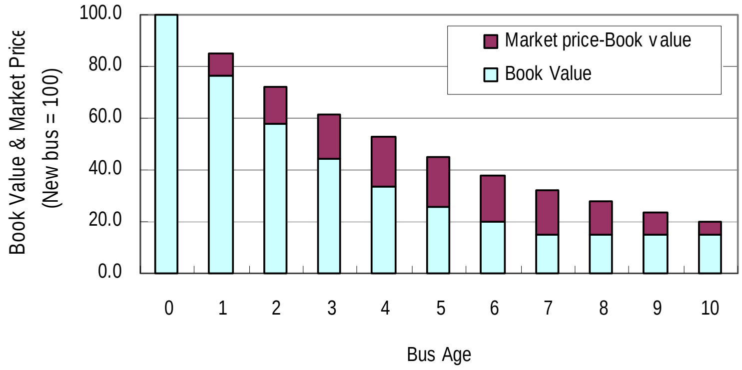


Figure 20.3-5 Devaluation of Buses by Age

Table 20.3-2 Appraisal of Used Bus for Trunk Bus System

(Unit: R$1000)

Bus Age	Fleet	Residual Coefficient	New Car Price w/o Tax	Appraised Value
0	35	1.0000	115,848	4055
1	35	0.8513	115,848	3452
2	35	0.7248	115,848	2939
3	35	0.6170	115,848	2502
4	35	0.5253	115,848	2130
5	35	0.4472	115,848	1813
6	35	0.3807	115,848	1544
7	35	0.3241	115,848	1314
8	35	0.2759	115,848	1119
9	35	0.2349	115,848	953
Total	350	-	-	21820

Note: "w/o Tax" means "Without" Tax.

20.3.4. BUS PROCUREMENT PLAN

Based on the transport demand forecast, future needs of bus fleet increase were estimated as shown in Table 20.3-3. The replacement demand during the first decade (2008 – 2017) is to renew the used buses introduced at opening. After 2017, the replacement will enter the second round. Twenty-one articulated buses and seven feeder buses bought in 2008 have to be replaced in 2018.

All the busses are order-made in Brazil and a large order will result in a bargain price. Then, to increase the bus fleet every year is not realistic. Hence, it was assumed that new buses were purchased every three years in advance. Thus, the bus procurement plan and fleet cost were as shown in Table 20.3-4. As an articulated bus costs R$470,000 and a standard bus costs R$88,000 at 2003 prices, the total cost in 2007 – 2026 will be R$240.9 million (R$226.5 million for articulated buses and R$14.3 million for feeder buses) This total amount corresponds to the fare revenue of 1.4 years.

Table 20.3-3 Required Bus Procurement for Trunk Bus System

(Bus unit)

Year	Articulated Trunk Buses (200 pax)			Feeder Buses (70pax)		
	Replace-ment	For Demand Increase	Total	Replace-ment	For Demand Increase	Total
2007	0	0	0	0	0	0
2008	15	6	21	5	2	7
2009	15	6	21	5	2	7
2010	15	6	21	5	2	7
2011	15	59	74	5	17	22
2012	15	7	22	5	3	8
2013	15	2	17	5	1	6
2014	15	1	16	5	1	6
2015	15	2	17	5	1	6
2016	15	2	17	5	1	6
2017	15	1	16	5	1	6
2018	21	2	23	7	1	8
2019	21	1	22	7	2	9
2020	21	2	23	7	1	8
2021	74	1	75	22	0	22
2022	22	2	24	8	1	9
2023	17	1	18	6	0	6
2024	16	2	18	6	1	7
2025	17	1	18	6	0	6
2026	17	2	19	6	1	7

Table 20.3-4 Schedule and Cost of Bus Procurement

(Bus unit; R$ million)

Year	Bus to Be Procured		Fleet Cost		
	Articulated	Standard	Articulated	Standard	Total
2007	63	21	29.6	1.8	31.5
2010	113	36	53.1	3.2	56.3
2013	50	18	23.5	1.6	25.1
2016	61	23	28.7	2.0	30.7
2019	122	39	57.3	3.4	60.8
2022	54	19	25.4	1.7	27.1
2025	19	7	8.9	0.6	9.5
Total	482	163	226.5	14.3	240.9

20.3.5. FARE REVENUE OF TRUNK BUS SYSTEM

(1) Daily Passengers of Trunk Bus System

According to the results of the demand forecast, the number of passengers of the trunk bus system will increase as shown in Table 20.3-5. A significant increase from 2007 to 2012 is due to the new trunk bus route along Av. Independencia and after 2012, a slight increase at 0.8 – 1.0% p.a. will continue. As not all the passengers pay the bus fare, several adjustments are necessary to estimate the fare revenue.

Table 20.3-5 Daily Passenger of Trunk Bus and Feeder Bus

(1000 pax/day)

Kind of Bus	2007	2012	2020
Trunk Bus	638.9	958.9	1028.0
Feeder Bus	376.4	532.3	591.5
Total	1015.3	1491.2	1619.5

(2) Pay-Passenger and Annual Fare Revenue

It was planned for the trunk bus system to offer a free transfer between trunk buses and feeder buses. Accordingly, such a free ride after transferring should be considered. Table 20.3-6 shows the number of transfer passengers by mode.

Table 20.3-6 Transfer Passengers

(1,000 pax/day)

Year	From To	Trunk Bus	Feeder Bus	Conventional Bus	Total
2002	Trunk Bus	-	-	-	-
	Feeder Bus	-	-	-	-
	Conventional Bus	-	-	415.8	415.8
	Total	-	-	415.8	415.8
2007	Trunk Bus	59.4	169.4	122.6	351.3
	Feeder Bus	173.9	13.3	91.3	278.5
	Conventional Bus	99.0	98.1	385.0	582.1
	Total	332.3	280.8	598.8	1,211.9
2012	Trunk Bus	86.6	231.8	154.9	473.2
	Feeder Bus	259.0	17.5	65.7	342.2
	Conventional Bus	149.6	82.0	358.3	589.8
	Total	495.1	331.3	578.9	1,405.3
2020	Trunk Bus	102.3	257.2	161.3	520.8
	Feeder Bus	287.6	20.0	70.4	378.0
	Conventional Bus	162.5	87.0	373.9	623.5
	Total	552.4	364.2	605.6	1,522.3

Besides the free-ride transferring passengers, there are many bus passengers who are legally free from bus fare payment. They are infants, the handicapped, the aged, policemen and so on. According to an on-board survey carried by the EVPDTU in 2002, about 23% of bus passengers were free riders. In addition, the CTBel data indicates that about 36% of bus passengers ride a bus paying a 50% discounted fare. After adjustment for these passengers, the paying passenger equivalent was estimated at about 60%. In other words, a bus passenger does not pay R$ 1.00 per ride, but R$ 0.6 on average.

Table 20.3-7 shows the paying passenger equivalent and annual fare revenue. Here, one year is counted as 307 days, regarding week-end days and a holidays as 0.5 day. The fare revenue of the trunk bus system including feeder buses is estimated to be R$172 million, 32% of the total bus revenue.

Figure 20.3-6 illustrates the trend of daily passengers of the trunk bus system, divided into “paying passenger” and “non-paying passenger”. The latter will account for about 40% of the total, which the management of the trunk bus system would be burdened with.

Table 20.3-7 Paying Passenger Equivalent and Annual Fare Revenue

Item	Kind of Bus	2002	2007	2012	2020
Excluding Transfer Passenger (1000 pax/day)	Trunk bus passenger	-	439	663	696
	Feeder bus passenger	-	194	283	314
	Conventional bus passenger	2,069	1,787	1,713	1,768
	Total	2,069	2,420	2,659	2,778
Pay-passenger Equivalent (1000 pax/day)	Trunk bus passenger	-	260	392	412
	Feeder bus passenger	-	115	167	186
	Conventional bus passenger	1,224	1,057	1,014	1,046
	Total	1,224	1,432	1,573	1,644
Annual Income (R$ million/yr)	Trunk/Feeder bus system	-	115	172	184
	Conventional bus passenger	458	395	379	391
	Total	458	510	551	575

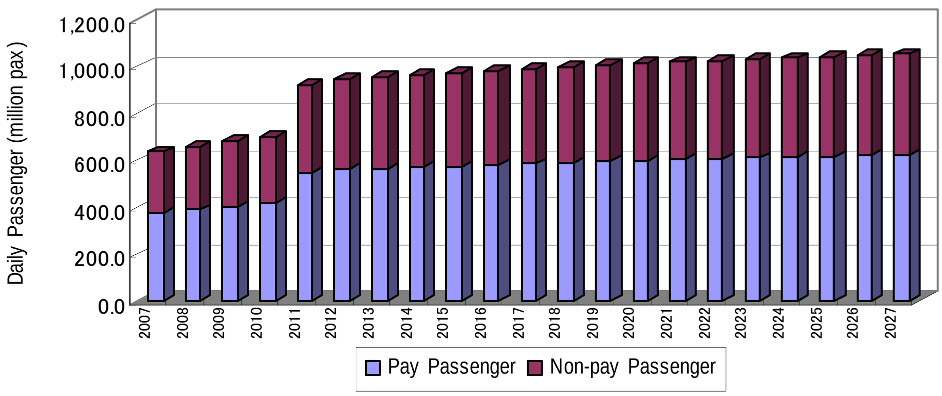


Figure 20.3-6 Passenger of Trunk Bus System

20.3.6. OPERATING COST OF TRUNK BUS SYSTEM

The CTBel (Belem Transport Company) updates the operating cost of a large bus every year as basic data for bus fare revision. According to the data, the operating cost was R$2.09 per km in 2001, including tax. The composition of cost components was as shown in Figure 20.3-7. The variable cost accounted for 35% of the total, the fixed cost for 55.6% and tax for 9.7%.

Based on the data, the unit operating cost of a large bus (100 passenger) in 2003 was estimated as shown in Table 20.3-8. The operating cost of a standard bus (70 passengers) is about 65% of the large bus and the cost of a standard bus is 1.8 times that of the large bus.

Using the unit cost and annual operating distance, the cost of annual operating expenditure was estimated as shown in Table 20.3-9. In this operating cost, such costs as depreciation, board remuneration and tax are excluded because they were calculated separately in the financial model.

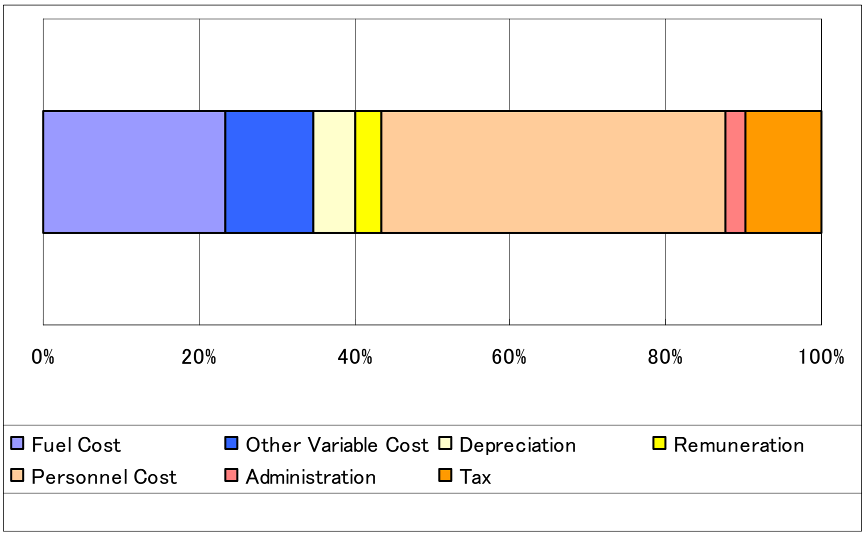


Figure 20.3-7 Bus Operating Cost by CTBel

Table 20.3-8 Unit Operating Cost of Large Bus in 2003

Cost Item	Actual Performance		R$/km	% to Cost	% to Total	%Tot. with Tax
	R$/Veh. /Month	(R$ Million/ Month)				
F1. Variable Cost						
Fuel			0.6635	67.23	25.84	23.35
Lubricant			0.0752	7.62	2.93	2.65
Wheelwork			0.1263	12.80	4.92	4.45
Parts and Accessories			0.1219	12.34	4.74	4.29
Total Variable Cost			0.9870	100.00	38.44	34.73
F2. Fixed Cost						
Depreciation	1,023	1,906.7	0.1537	9.73	5.99	5.41
Vehicle	1,009	1,880.9	0.1518	9.60	5.91	5.34
Machines Facilities and Equipment	14	25.8	0.0020	0.13	0.08	0.07
Remuneration	642	1,197.1	0.0966	6.11	3.76	3.40
Vehicle	541	1,008.0	0.0813	5.15	3.17	2.86
Machines Facilities and Equipment	55	103.3	0.0083	0.53	0.32	0.29
Warehouse	46	85.8	0.0069	0.44	0.27	0.24
Expenses with Personnel	9,142	15,505.7	1.2513	79.16	48.73	44.03
Operation	6,478	10,987.2	0.8867	56.09	34.53	31.20
Maintenance	875	1,483.3	0.1197	7.57	4.66	4.21
Administrative	680	1,153.7	0.0932	5.89	3.63	3.28
Benefits	929	1,574.8	0.1270	8.04	4.95	4.47
Board Remuneration	181	306.8	0.0248	1.57	0.96	0.87
Administrative Expenses	524	977.7	0.0789	4.99	3.07	2.87
General	346	645.7	0.0521	3.30	2.03	1.83
Civil Responsibility Insurance	66	122.5	0.0099	0.63	0.39	0.35
Mandatory Insurance	35	64.4	0.0052	0.33	0.20	0.18
IPVA	78	145.0	0.0117	0.74	0.46	0.41
Total Fixed Cost	11,332	19,587.1	1.5807	100.00	61.56	55.62
F3. Total Cost			2.5678		100.00	90.35
F4. Total Cost with Taxes			2.8424			9.65
						100.00

Table 20.3-9 Annual Operating Cost of Trunk Bus System

(R$ million)

Year	Operating Distance (million veh.-km)		Operating Cost (R$ million at 2003 price)			
	Trunk Bus	Feeder Bus	Management*	Trunk Bus	Feeder Bus	Total
2007	15.90	6.70	2.8	62.5	26.3	91.6
2011	23.35	9.36	2.8	91.8	36.8	131.3
2012	24.16	9.85	2.8	94.9	38.7	136.5
2020	25.64	11.08	2.8	100.7	43.5	147.1

Note: Management cost is operating cost of Trunk Bus System Management Unit (TBSMU)

20.3.7. RESULT OF FINANCIAL EVALUATION

(1) Additional Assumptions for Financial Analysis

The financial statements were forecast based on the following assumptions on inflation, interest rate, tax and others.

1) Inflation rate

In the mid-1990s, the Brazilian hyperinflation settled down to the level of 5.0 – 14% per annum (see Figure 20.3-8). The average during 1996 – 2003 was 9.2% but the recent trend is slightly upward. In this analysis, the inflation rate was set at 11.0% per annum during the project life (2004 – 2027).

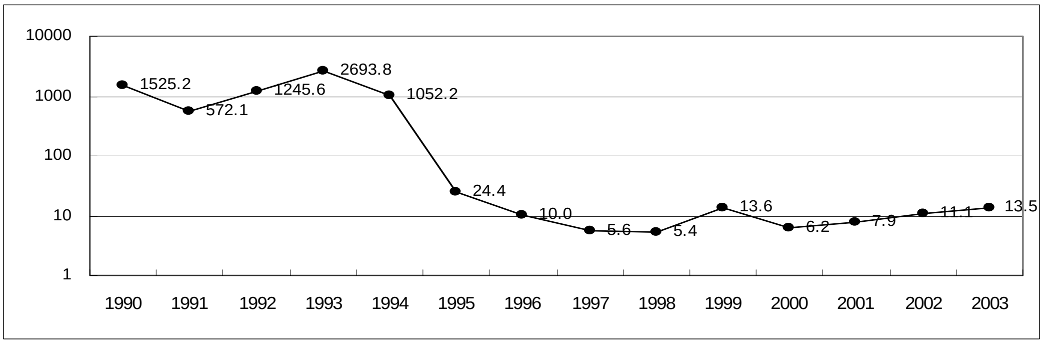


Figure 20.3-8 Trend of Inflation in Brazil

2) Interest rate

CTBel's analysis assumes a 12.0% interest rate. However, the recent interest rate of the BNDES shows a higher rate of 11.0 – 19.0 as shown in Figure 20.3-9. In this analysis, a 15% annual interest rate was assumed. By this, the interest rate in the real terms is 3.6% per annum ((1+0.15)/(1+0.11)-1).

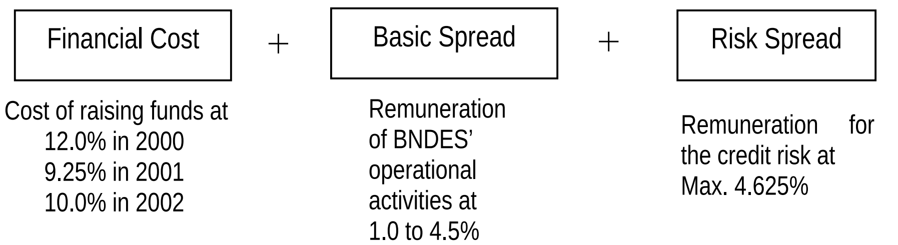


Figure 20.3-9 Recent Interest Rate of BNDES

3) Tax

The tax system in Brazil is complicated and somewhat flexible. The tax rate is often changed. In this analysis, the tax rate in Table 20.3-10 was assumed, referring to the current rate. The vehicle purchase tax is already included in the car price.

Table 20.3-10 Taxation used in Financial Analysis

Kind of Tax	Tax	Tax imposer	Tax Rate	Note
Business Tax	IRPJ	Federal Gov.	27.5%	On annual profit
	ISS	Municipality	5.0%	On avalue added
Vehicle Ownership Tax	IPVA	State Gov.	1.0%	On residual value
Vehicle Acquisition Tax	ICMS	State Gov.	12.0%	On Vehicle price
	ISS	Municipality	5.0%	On Vehicle price

IRPJ: Corporate income tax

ISS: Service tax (value added tax)

IPVA: Vehicle property tax

ICMS: Tax on Circulation and Service (State Tax)

(2) Financial Statement

The pro-forma financial statements were formulated for both nominal and real terms, using the various estimates and assumptions stated in this section. The results were favorable as shown below.

1) Analysis in 2003 Constant Price

Cash flow of the project was evaluated from two points of view: one is the net cash flow of the project as a whole, and the other is the cash flow from the viewpoint of the investors (or equity holders). Each cash flow is defined as follows:

- Project Cash Flow = Net Income before depreciation - Investment
- Equity Cash Flow = Cash in Hand – Equity Investment

Table 20.3-11 shows the profit and loss statement of the project. The net operating income from 2007 to 2027 is R$ 665.1 million while and the average fare-box ratio (revenue/ operating expense) is 1.23, which suggests a moderate profitability. During the period of 2008 – 2011, the net income after tax will be negative but the absolute amounts are less than depreciation amount and then the cumulative cash flow can keep positive.

Table 20.3-12 presents main indicators of the cash flow and the balance sheet and several ratios of revenue vs. expense, liability vs. asset and return vs. assets, all of which are in a reasonable range.

Figure 20.3-10 and Figure 20.3-11 show the annual cash flow and the cumulative cash flow, respectively. Based on these cash flows, evaluation indicators were calculated as in Table 20.3-12.

One of the remarkable characteristics of this project is that the earnings by bus operation and investment for bus fleet expansion are simultaneously going on and then a positive and a negative cash flow appear alternately. Consequently, the resultant F-IRR becomes unstable. Under the given conditions, the project IRR is very high at 40.9% and Equity IRR is 20.3%, which is generally a satisfactory level. Especially in case of the equity IRR, however, the initial investment amount is comparatively small and then the NPV is a small amount of R$6.6 million, even with such a high F-IRR (Table 20.3-13 and Table 20.3-14).

Table 20.3-11 Profit/Loss Statement of Trunk Bus Business

Year	Fare Revenue	Operating Expense	Net Operating Income before Deprecication	Depre-ciation	Interest Paid	Vehicle Tax (IPVA)	Disposal of Old Bus	Net Operating Income	Tax		Net Profit after Tax
									Corporate Income Tax (IRPJ)	Service Tax (ISS)	
2007	115.0	91.6	23.4	5.2	0.0	0.2	0.0	18.0	5.0	5.8	7.3
2008	119.0	100.2	18.7	12.8	4.7	0.5	4.4	5.2	1.4	5.9	-2.2
2009	123.0	109.7	13.4	9.4	3.8	0.4	4.4	4.3	1.2	6.2	-3.0
2010	127.3	120.0	7.3	6.9	2.8	0.3	4.4	1.7	0.5	6.4	-5.1
2011	166.4	131.3	35.1	20.8	10.3	0.8	4.4	7.6	2.1	8.3	-2.8
2012	171.8	136.5	35.3	15.1	7.7	0.5	4.4	16.4	4.5	8.6	3.3
2013	173.2	137.7	35.4	10.9	5.1	0.4	4.4	23.5	6.5	8.7	8.4
2014	174.6	139.0	35.6	14.1	7.1	0.5	8.7	22.4	6.2	8.7	7.5
2015	176.1	140.4	35.7	9.3	4.7	0.4	4.4	25.8	7.1	8.8	9.9
2016	177.5	141.7	35.9	6.7	2.3	0.2	4.4	31.1	8.6	8.9	13.7
2017	179.0	143.0	36.0	13.4	6.1	0.5	12.0	28.0	7.7	9.0	11.4
2018	180.5	144.4	36.2	8.1	4.4	0.3	0.0	23.3	6.4	9.0	7.9
2019	182.0	145.7	36.3	5.8	2.8	0.2	0.0	27.5	7.6	9.1	10.9
2020	183.6	147.1	36.5	21.2	11.0	0.8	3.4	6.9	1.9	9.2	-4.2
2021	184.6	148.5	36.1	14.6	8.2	0.5	0.0	12.8	3.5	9.2	0.0
2022	185.6	149.9	35.7	10.5	5.5	0.4	0.0	19.4	5.3	9.3	4.8
2023	186.6	151.3	35.3	15.1	7.7	0.5	4.1	16.1	4.4	9.3	2.3
2024	187.6	152.7	34.9	10.0	5.1	0.4	0.0	19.4	5.3	9.4	4.7
2025	188.7	154.1	34.5	7.2	2.4	0.3	0.0	24.6	6.8	9.4	8.4
2026	189.7	155.6	34.1	7.9	3.1	0.3	8.2	31.1	8.6	9.5	13.1
2027	190.8	157.1	33.7	4.0	2.0	0.2	0.0	27.6	7.6	9.5	10.5
Total	3562.6	2897.5	665.1	228.8	106.7	8.5	71.8	392.9	108.0	178.1	106.7

Table 20.3-12 Main Financial Indicators and Cash Flow for Evaluation

Year	Investment (Bus Purchase)	Loan Repay-ment	Asset and Liability			Cash Flow for Project IRR	Cash Flow for Equity IRR	Annual Evaluation		
			Liability	Current Asset	Fixed Asset (Bus)			Fare Box Ratio	Debt Ratio	Net Return on Asset
2007	31.5	0.0	0.0	7.3	21.8	-21.8	-21.8	1.26	0.00	0.62
2008	0.0	6.3	25.2	5.1	48.1	-8.0	12.5	1.19	0.47	0.10
2009	0.0	6.3	18.9	2.1	32.1	23.2	4.3	1.12	0.55	0.13
2010	56.3	6.3	12.6	-3.0	22.7	17.8	0.0	1.06	0.64	0.09
2011	0.0	17.5	51.3	-5.8	72.1	-44.6	-4.5	1.27	0.77	0.11
2012	0.0	17.5	33.8	-2.5	51.3	39.5	0.5	1.26	0.69	0.34
2013	25.1	11.3	22.5	5.9	36.2	39.7	0.8	1.26	0.53	0.56
2014	0.0	16.3	31.3	13.4	50.4	14.8	8.0	1.26	0.49	0.35
2015	0.0	16.3	15.1	23.3	29.9	44.2	5.4	1.25	0.28	0.49
2016	30.7	5.0	10.0	37.0	20.6	40.1	2.9	1.25	0.17	0.54
2017	0.0	11.2	29.6	48.3	44.6	9.6	15.3	1.25	0.32	0.30
2018	0.0	11.2	18.4	56.2	25.5	48.0	13.6	1.25	0.23	0.29
2019	60.8	6.1	12.3	67.1	20.7	36.2	4.8	1.25	0.14	0.31
2020	0.0	18.3	54.8	62.9	75.7	-24.5	10.5	1.25	0.40	0.05
2021	0.0	18.3	36.5	62.9	52.0	39.9	-1.2	1.24	0.32	0.11
2022	27.1	12.2	24.3	67.7	37.4	36.1	-3.7	1.24	0.23	0.18
2023	0.0	17.6	33.8	70.1	54.0	8.7	3.1	1.23	0.27	0.13
2024	0.0	17.6	16.2	74.8	35.8	39.5	-0.1	1.23	0.15	0.18
2025	9.5	5.4	10.8	83.2	25.7	34.9	-2.8	1.22	0.10	0.23
2026	0.0	7.3	13.0	96.3	28.1	25.0	10.2	1.22	0.10	0.25
2027	0.0	7.3	5.7	106.7	14.1	42.3	13.6	1.21	0.05	0.23
Total	240.9	235.2	-	-	-	440.5	71.5	-	-	-

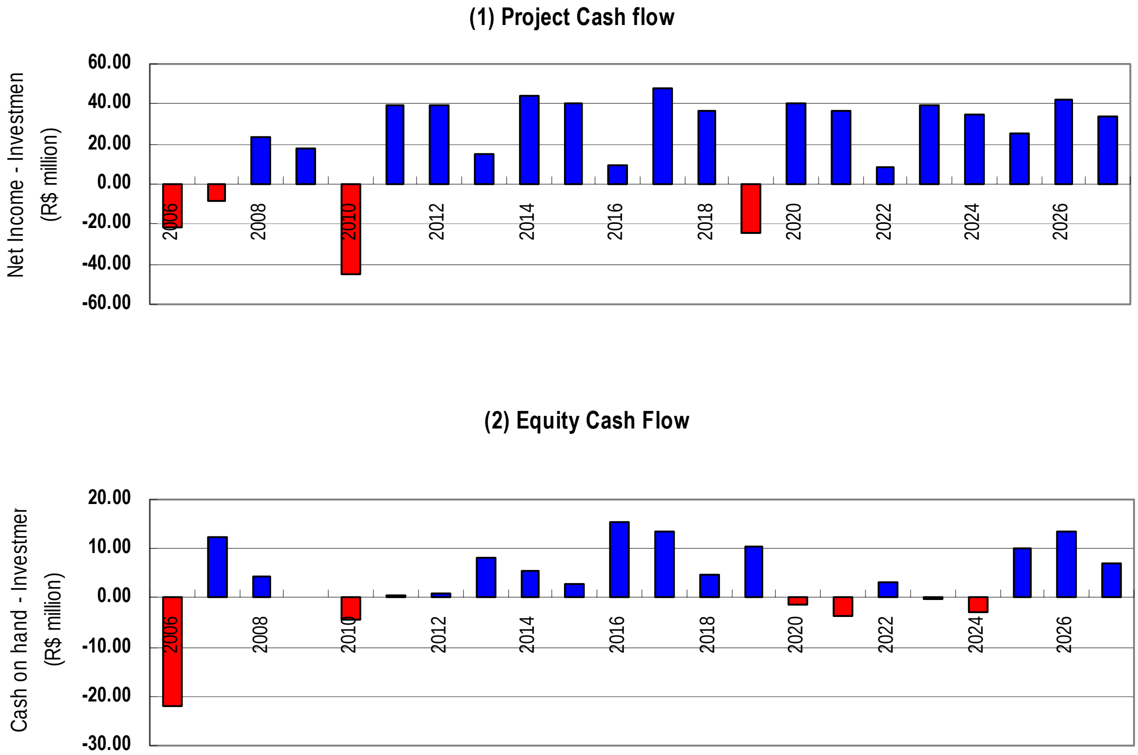


Figure 20.3-10 Cash Flow of Trunk Bus Business

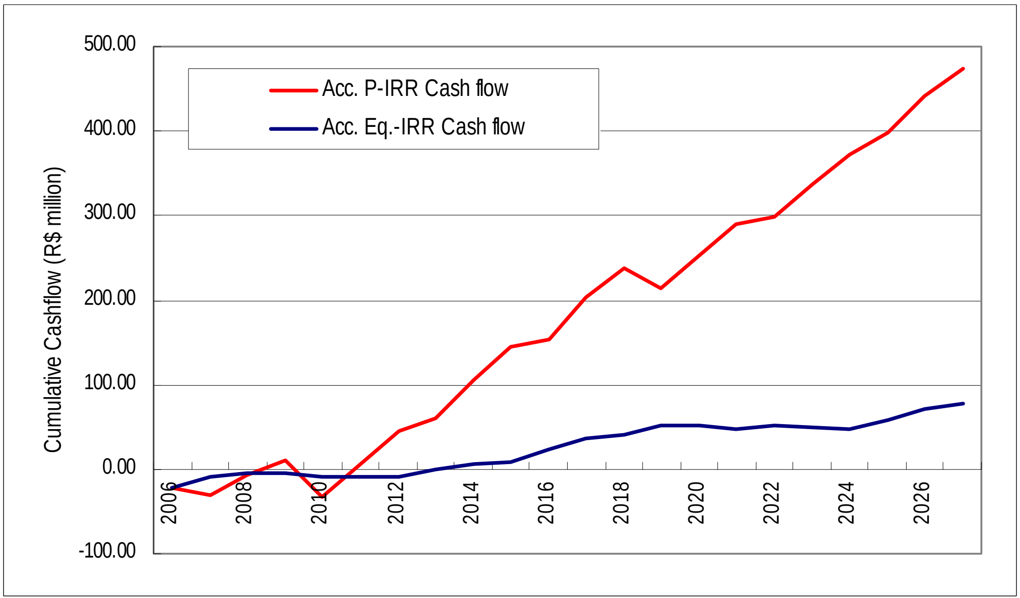


Figure 20.3-11 Cumulative Cash Flow of Trunk Bus Business

Table 20.3-13 Evaluation Indicators of Trunk Bus Business

Indicators	Project	Equity Holder
Financial IRR (%)	40.9	20.3
NPV（R$ million）at 15%	82.2	6.6

Table 20.3-14 Sensitivity of Financial IRR and NPV

Factor to Change	Conditions	Project Evaluation		Shareholder's Evaluation	
		Project IRR	NPV	Equity IRR	NPV
		%	R$ million	%	R$ million
Base Case	-	40.9	82.2	20.3	6.6
Revenue	5% UP	43.7	90.7	24.9	12.8
	5% down	38.1	73.7	15.4	0.4
	10% down	35.4	65.2	9.7	-5.7
Price of Bus	10% down	45.2	91.2	25.0	13.1
	10% up	36.9	73.2	15.2	0.2
	20% up	33.3	64.2	9.3	-6.3
Tax	10% down	-	-	25.7	14.0
	10% up	-	-	17.4	7.9
	20% up	-	-	14.4	-0.7
Interest Rate	15% - 2.5%	-	-	23.0	10.2
	15% + 2.5%	-	-	17.5	3.1
	15% + 5.0%	-	-	14.6	-0.5

2) *Analysis at Current Price*

Under a fixed interest rate and scheduled repayment, cash flow is favorably affected by inflation because every item of revenue and cost is escalated by inflation and the amount of principal repayment and interest becomes relatively less. Figure 20.3-12 shows the cash flow, and Figure 20.3-13 is the cumulative cash flow under 11% inflation. Comparing Figure 20.3-10 and Figure 20.3-11, the cash flows are much improved, and the resultant F-IRRs become much higher than those of the constant price case (Table 20.3-15). The actual interest rate includes an expected inflation rate, so the actual cash flow of the trunk bus project will be not like Figure 20.3-10, but like Figure 20.3-12.

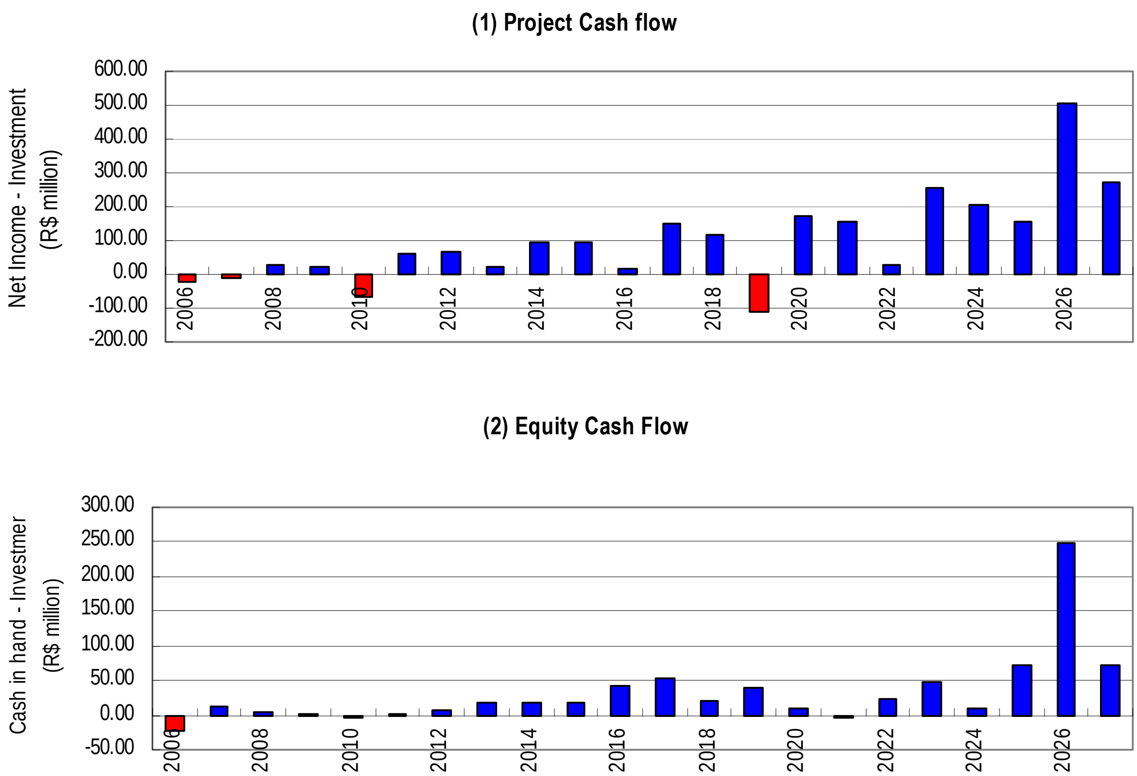


Figure 20.3-12 Cash Flow under 11% Inflation

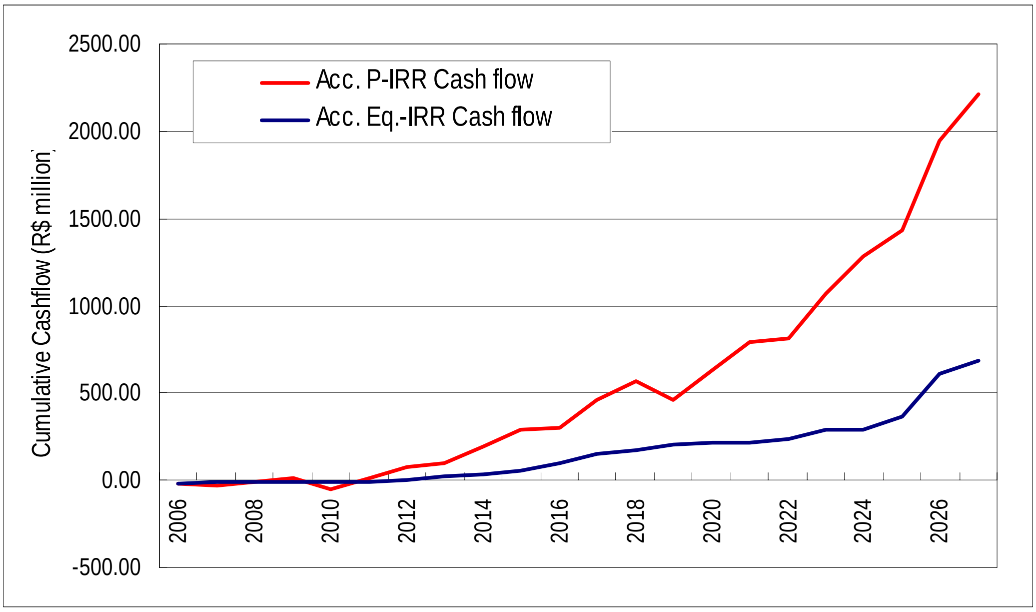


Figure 20.3-13 Cumulative Cash Flow of Trunk Bus Business

Table 20.3-15 Inflation and Financial IRR

Factor to Change	Conditions	Project Evaluation		Shareholder's Evaluation	
		Project IRR	NPV	Equity IRR	NPV
		%	R$ million	%	R$ million
Base Case	(11%)	50.6	273.1	37.3	76.4
Inflation	5%	45.2	138.3	27.1	22.6
	10%	49.7	242.4	35.7	63.4
	15%	54.4	454.3	43.9	158.5

(3) Conclusion

1) The Trunk Bus System is highly feasible financially both from the Project-IRR and the Equity-IRR points of view.

2) In the fourth year (2010) and the period of 2020 - 2025, the fund will be shorted about R$ 3.0 – 4.5 million due to the repayment of the loan, for which a three-year grace period is desirable.

3) Equity-IRR is very sensitive to the bus fare level and tax level. Equity–IRR falls lower than 15%, if the fare becomes less than 92% of the current R$ 1.00 per one ride, or if the price of a bus becomes higher than 1.1 times of the assumed one. Therefore, careful monitoring of inflation and operating cost is needed.

CHAPTER 21
Transport Demand Management (TDM)

21. TRANSPORT DEMAND MANAGEMENT (TDM)

21.1. INTRODUCTION

The Feasibility study in BMA is formulated in accordance with the future travel demand shown in Chapter 9. In 2012, the traffic volume in the morning peak period in the Study Area will rise 1.43 times the present one, of which 1.95 times are for car traffic and 1.22 times are for public transport. In the future, the increase ratio of car traffic volume will be considerably higher than that of the public one.

In the study, several major road projects and trunk bus system project are planned to improve the urban traffic and public transportation in the BMA. The both projects complement each other. For example, the road project, especially Av. Independencia is indispensable to the trunk bus system. This road is indispensable not only to improve the public transport system in BMA, but also to alleviate traffic congestion caused by private vehicles. The target year of the study is 2012 when the proposed projects are well balanced with future travel demand. In 2020, the travel demand will rise 1.89 times the present one. The proposed road and public transport projects will be insufficient to meet the future traffic volume after 2012. The proposed trunk bus system is gradually difficult in the balance of demand and supply after 2012.

Therefore, in order to improve the investment effect of projects, travel demand control will be indispensable in the future. Especially, it is important to divert the future travel demand from the private mode to the public mode to improve the service level in the whole Study Area. Figure 21.1-1 shows the eternal circle of demand and supply as mentioned above.

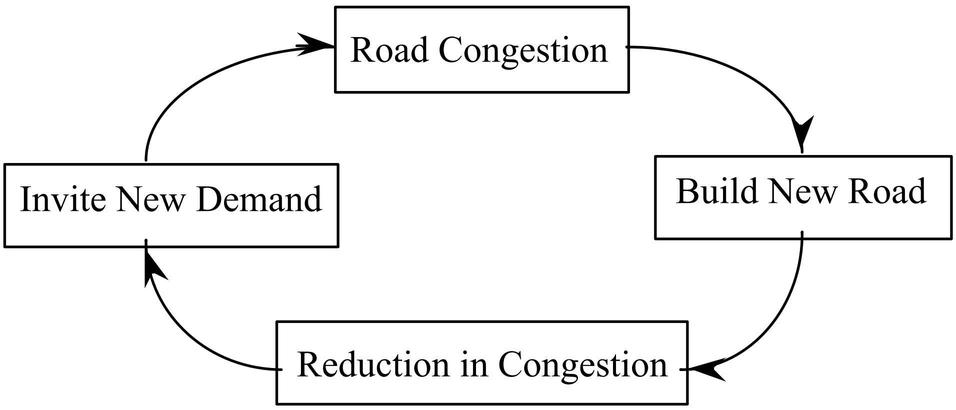


Figure 21.1-1 Eternal Circle of Demand and Supply

Recently, Transport Demand Management (TDM) developed in the United States is examined as a new management system as one of a strategic approach to avoid traffic congestion. Purposes of the demand control policy are to avoid future congestion through demand reduction efforts by any action or set of actions, and to obtain tax revenue, as a congestion tax from users, for transportation funding.

The measures of TDM are composed of growth management, road pricing, auto restricted zones, parking management, fuel tax, alternative work hours, etc. The introduction of TDM, however, is not easy because the passenger car is restricted from freedom of use, though several countries in Europe, Asia and U.S. have introduced or planned implementation. Therefore, it is indeed difficult to obtain a consensus of car owner regarding car use. Especially, the PT survey in the Study revealed that car owners have a very strong propensity to use a car, and that they will use a car whenever and wherever available.

In this chapter, TDM measures are examined, and its demand reduction effects, shifting traffic demand from the private mode to the public mode by discouraging use of private cars, are estimated in the light of better public transport service.

21.2. MEASURES OF TDM

The major measures of TDM are shown below. These are classified into 3 categories: to discourage car ownership, to discourage car use and to alleviate peak-time demand. These measures are to restrict car use or car ownership. These measures have to be introduced under the conditions that the service level of public transport rises sufficiently to encourage car users to shift to public transport. It is because car owners in Belem have very strong propensity to use a car, i.e., they will use a car whenever and wherever available.

1) To discourage car ownership
   - Planned Car Increase and Limited License Issue
   - High Taxation
2) To discourage car use
   - License-plate Numbering System
   - Road Pricing (Congestion Charge)
   - Area-Licensing (Congestion Charge)
   - HOV Priority System
   - Parking Control
   - Car User Tax
3) To alleviate peak-time demand
   - Staggered Working Time
   - Flex-time System

21.3. DIVERSION OF CAR MODE

(1) Procedure of Diversion of Car Mode

As mentioned before, future car trips considerably increase in comparison to the bus trips. In the target year of 2012, the traffic and transport service levels in terms of average travel speed and volume/capacity ratio will be close to a severe condition. Since the new trunk bus system will be provided with a rapid, economical and reliable system, it will be possible to divert private car users to the trunk bus.

Figure 21.3-1 shows the estimation of diversion of car mode to bus mode under several measurements of Transport Demand Management as mentioned above. In the examination of diversion of car mode in this section, the diversion of car mode is forecasted under the measures to discourage a car use by better service of the trunk bus system. Though there are some measures to discourage a car use as mentioned above, the examination does not associate with specific measures. This examination is conducted on the assumption that several measures are done in BMA.

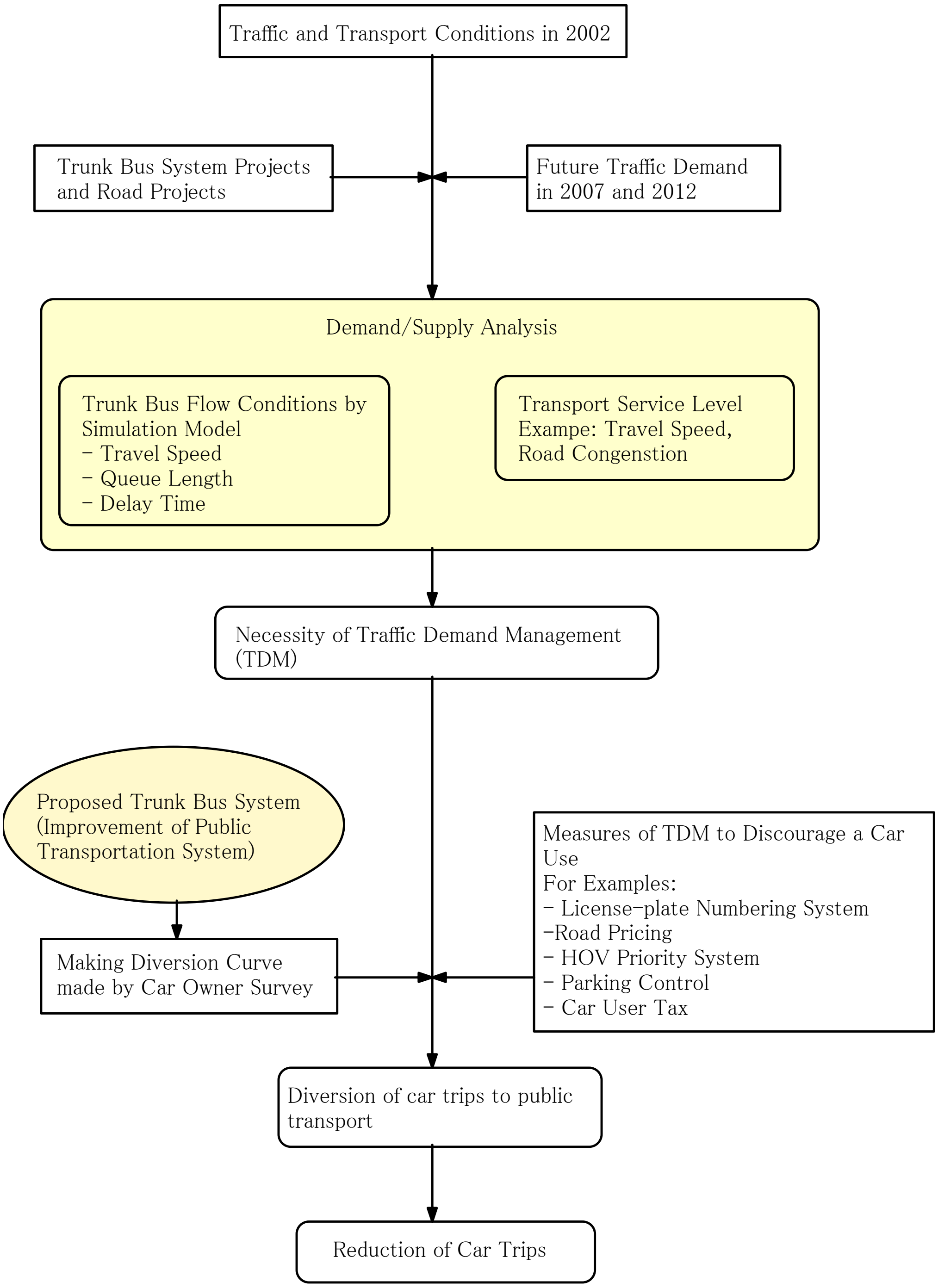


Figure 21.3-1 Estimation Flowchart for Transport Demand Management

As can be seen, the diversion of private car users was examined according to the data from a survey of a choice between bus under the trunk bus system and car. In the interview survey a sample of 300 was collected in October, 2002 and analyzed as shown in Figure 21.3-2, in which the diversion ratio of car users to the trunk buses is shown against time difference between car and bus travel times. As can be seen, it indicates that when the difference in travel time is 10 minutes, approximately 30% of car users will divert to the trunk buses. Incidentally, approximately 60% of interviewees are in the range of 10 to 30 minutes in the travel time.

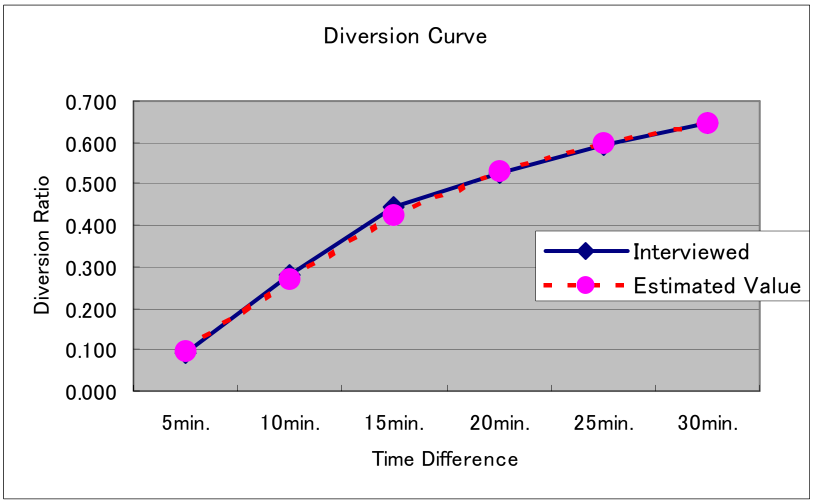


Figure 21.3-2 Diversion Curve of Car Users to Bus Transportation

Diversion's equation:

$$P=\frac{K}{1+\alpha\times(W/S)^{-\beta}}$$

Here:

P : Diversion ratio of car users to the trunk buses
W: Time difference (car travel time – bus travel time) minutes
K: 0.8
α : 162.457
β : −1.923
S: 0.752202 in 2012

(2) Projection of Diversion to Public Mode

The TDM analysis was done using the equation for the diversion for 2012, when the trunk bus system will be operated. In the estimation of bus travel time, the waiting time at bus stops, transfer time at bus stops and terminals, and walking time are included referring to the public transport survey data, while in the car trips those are not included. Table 21.3-1 shows the number of trips by type of vehicle in 2012 according to diversion of car trips. As can be seen, approximately 7% of the total car trips will divert to bus passengers in the morning peak hour. As a result, the total bus trips will increase by approximately 4%.

Table 21.3-1 Number of Trips by Diversion of Cars in 2012

	Base Case	After Analysis	Diversion Trips	Diversion Ratio
Daily Base				
Car	1,723,802	1,649,104	-74,698	-4.3%
Bus	2,088,226	2,162,924	74,698	3.6%
Peak Hour				
Car	216,825	201,641	-15,184	-7.0%
Bus	366,191	381,375	15,184	4.1%

According to the diversion of car users, in 2012, travel conditions will be improved as shown in Figure 21.3-3 and Figure 21.3-4 in which the estimated value is shown as a triangle symbol. The average travel speed is a typical index to show a service level. In the peak hour average travel speed in 2012, it is slightly better in the diversion case than that With project case (base case). The figure increases from 34 km/h in the base case to 41 km/h. This travel speed is the same as that at the present level (42km/h). The peak hour average volume/capacity ratio as a index of traffic congestion is somewhat better than that in base case. The figure decreases from 0.75 in the base case to 0.66 in the diversion case.

Although this is the sensitivity analysis, the introduction of the trunk bus system as well as road planning will be expected for the improvement of traffic and transport conditions.

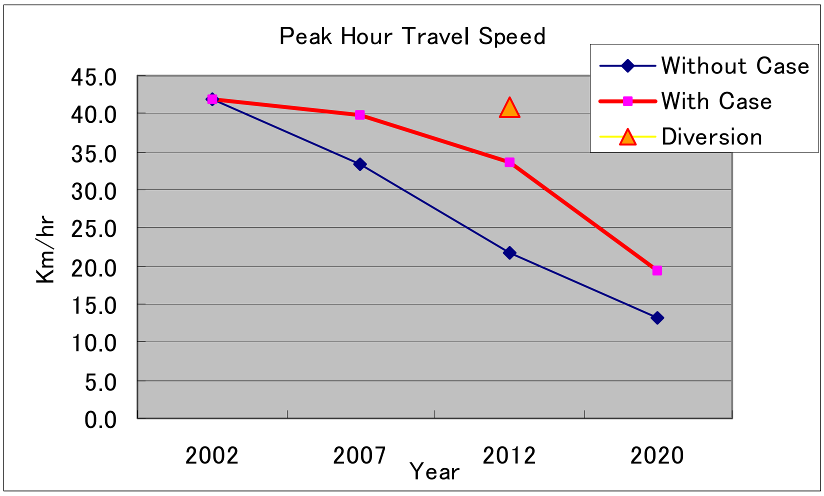


Figure 21.3-3 Peak Hour Average Travel Speed

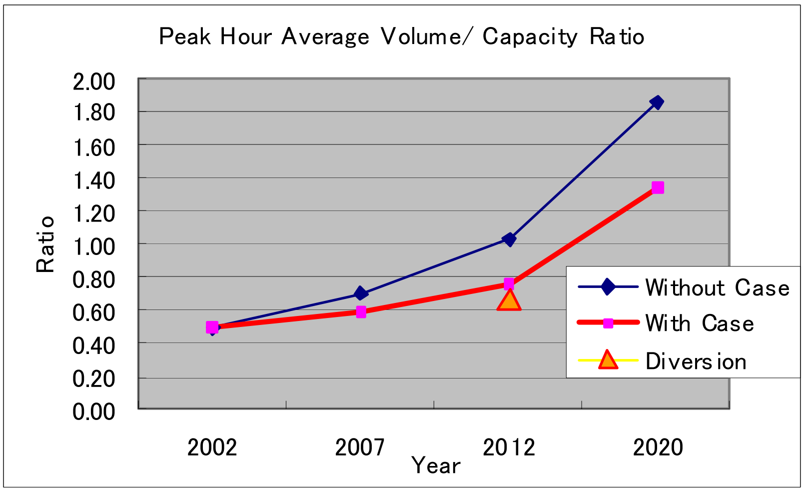


Figure 21.3-4 Peak Hour Average Volume/Capacity Ratio

APPENDIX

TABLE OF CONTENTS

List of Appendix Tables

List of Appendix Figures

Appendix A

Appendix B

Appendix D

Appendix-A

A.6 Initial Environmental Examination

A.6 INITIAL ENVIRONMENTAL EXAMINATION

(1) Air Quality Survey Results (NOX)

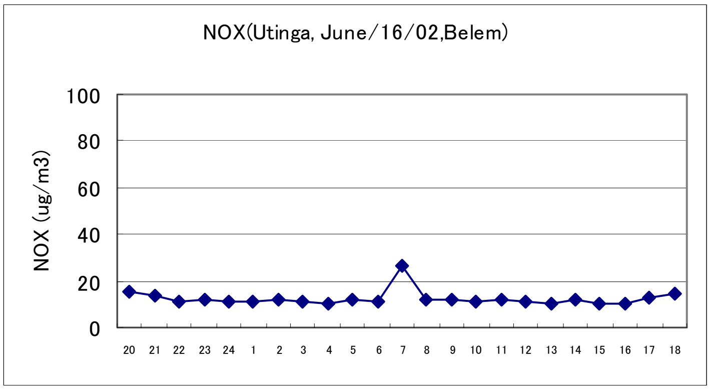


Figure A-1 Roadside A/Q Survey Results (NOX, Utinga, June/16/02)

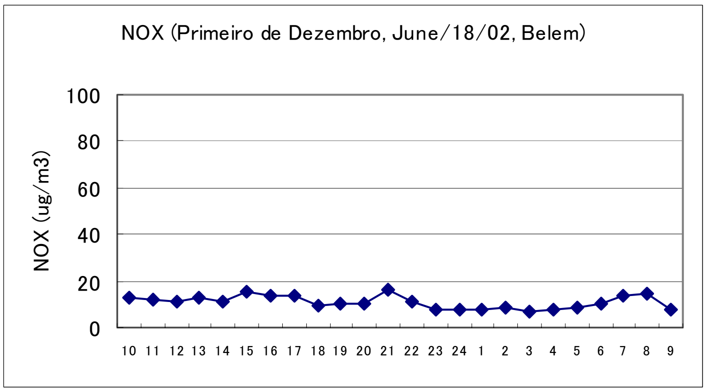


Figure A-2 Roadside A/Q Survey Results (NOX, Primeiro de Dezembro, June/18/02)

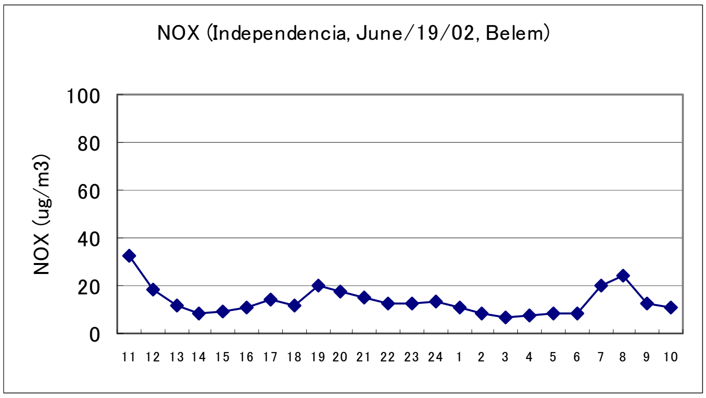


Figure A-3 Roadside A/Q Survey Results (NOX, Independencia, June/19/02)

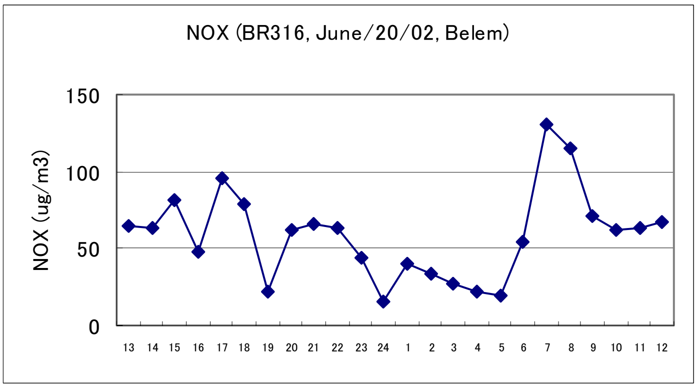


Figure A-4 Roadside A/Q Survey Results (NOX, BR316, June/20/02)

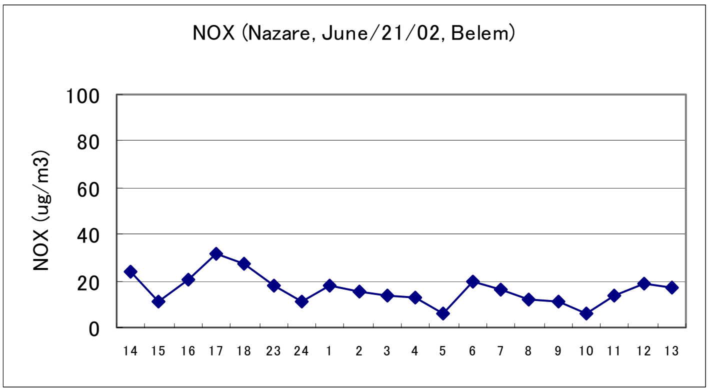


Figure A-5 Roadside A/Q Survey Results (NOX, Nazare, June/21/02)

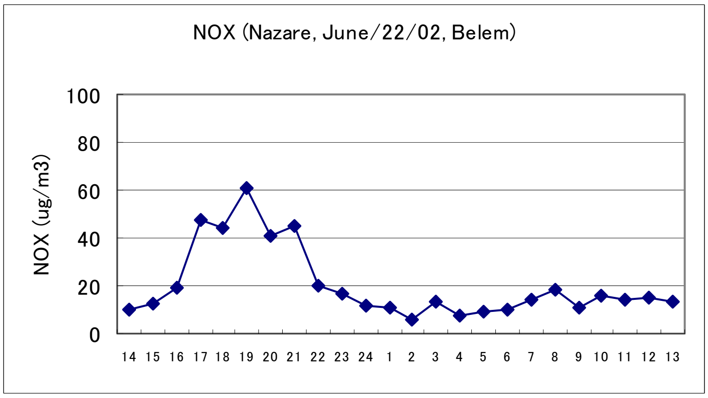


Figure A-6 Roadside A/Q Survey Results (NOX, Nazare, June/22/02)

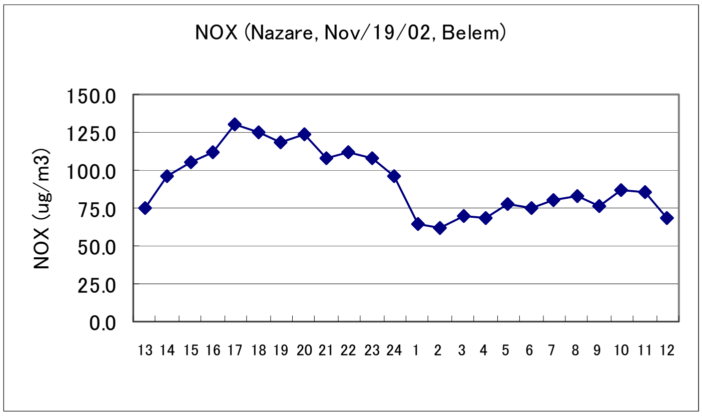


Figure A-7 Roadside A/Q Survey Results (NOX, Nazare, Nov/19/02)

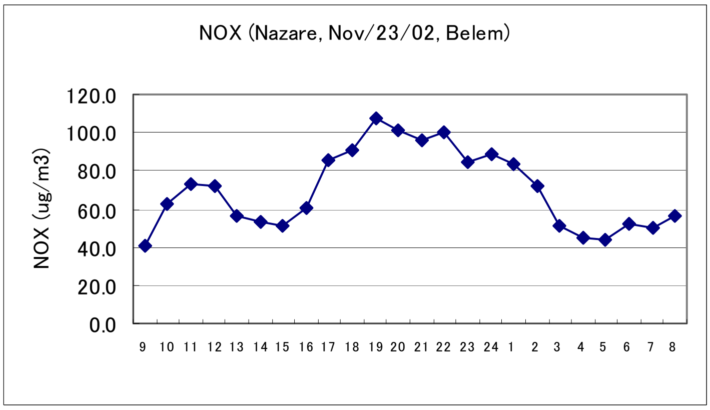


Figure A-8 Roadside A/Q Survey Results (NOX, Nazare, Nov/23/02)

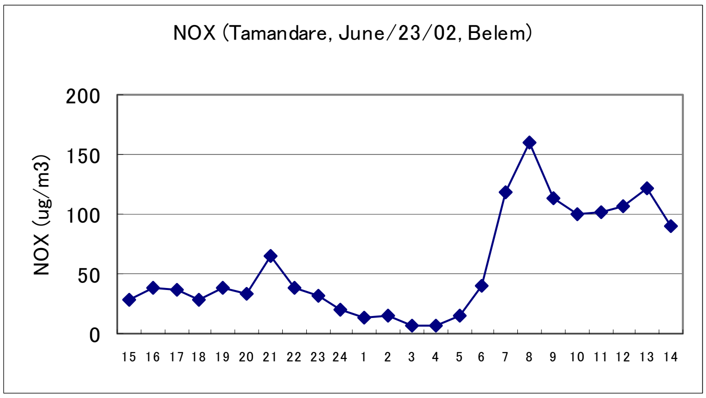


Figure A-9 Roadside A/Q Survey Results (NOX, Tamandare, June/23/02)

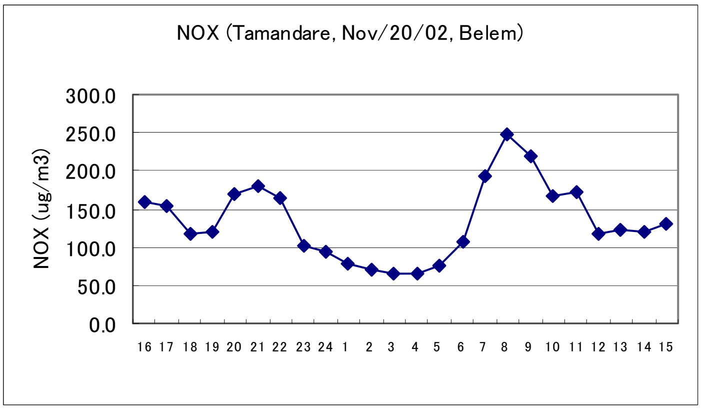


Figure A-10 Roadside A/Q Survey Results (NOX, Tamandare, Nov/20/02)

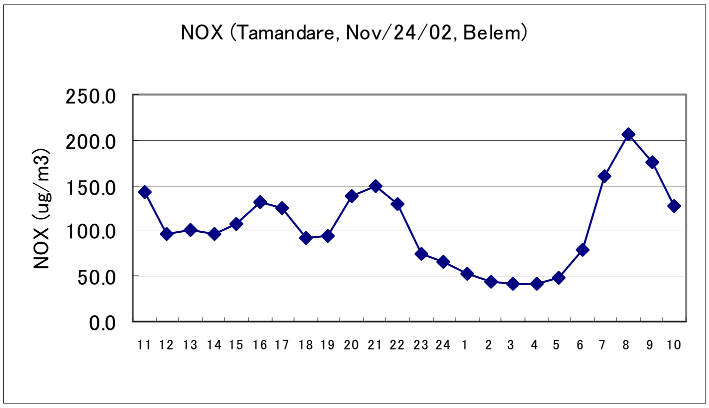


Figure A-11 Roadside A/Q Survey Results (NOX, Tamandare, Nov/24/02)

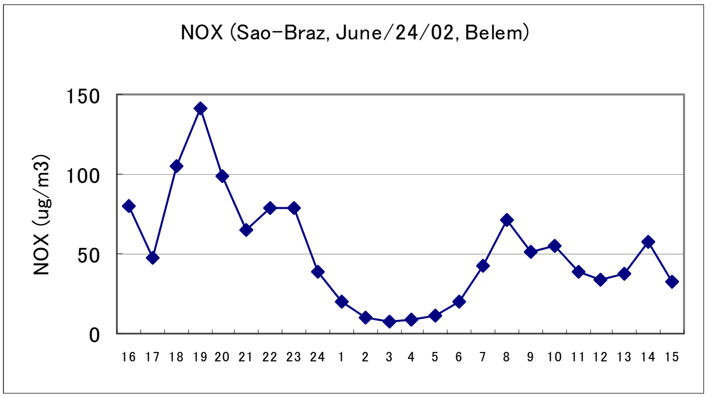


Figure A-12 Roadside A/Q Survey Results (NOX, Sao-Braz, June/24/02)

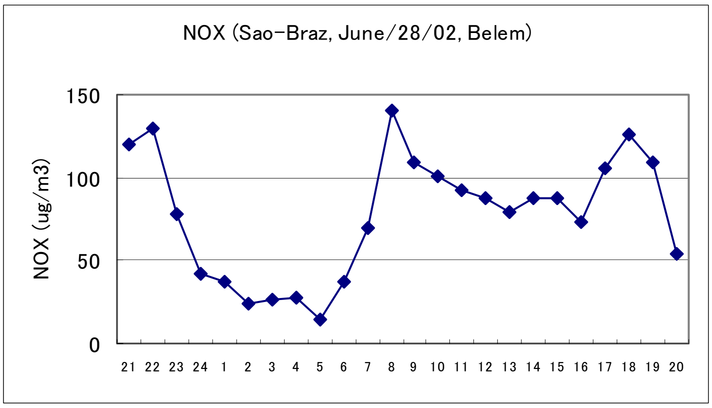


Figure A-13 Roadside A/Q Survey Results (NOX, Sao-Braz, June/28/02)

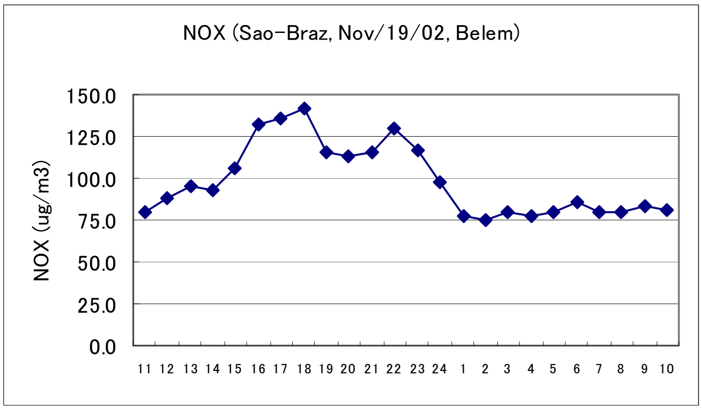


Figure A-14 Roadside A/Q Survey Results (NOX, Sao-Braz, Nov/19/02)

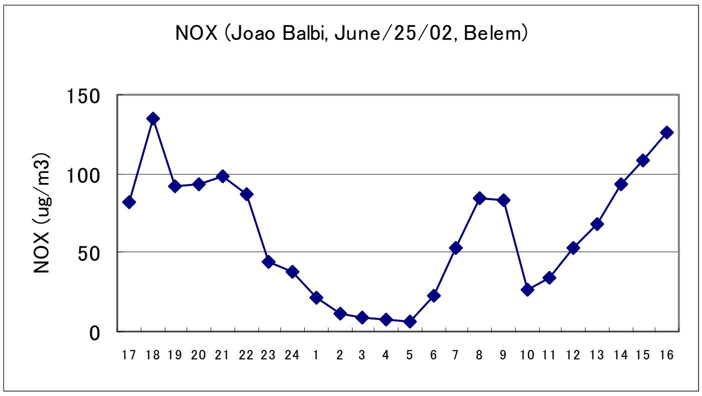


Figure A-15 Roadside A/Q Survey Results (NOX, Joao Balbi, June/25/02)

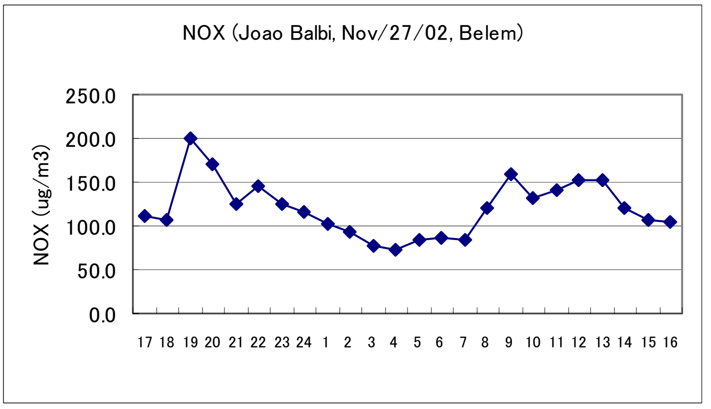


Figure A-16 Roadside A/Q Survey Results (NOX, Joao Balbi, Nov/27/02)

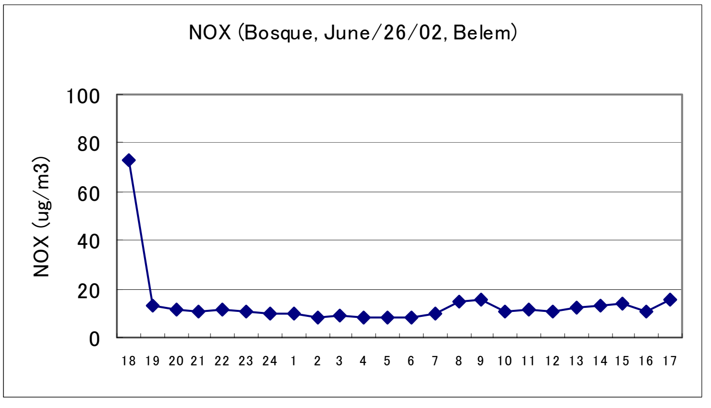


Figure A-17 Roadside A/Q Survey Results (NOX, Bosque, June/26/02)

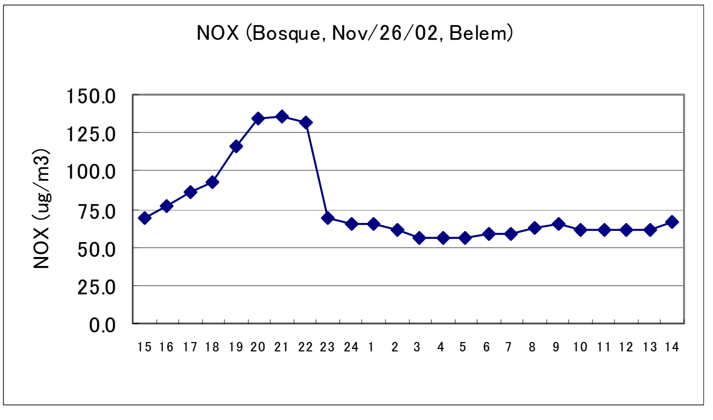


Figure A-18 Roadside A/Q Survey Results (NOX, Bosque, Nov/26/02)

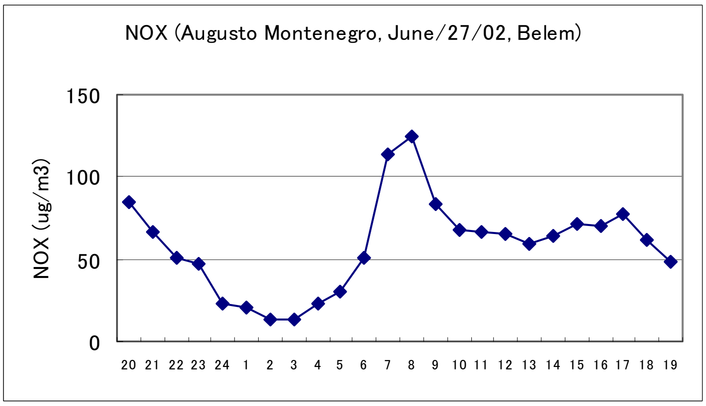


Figure A-19 Roadside A/Q Survey Results (NOX, Augusto Montenegro, June/27/02)

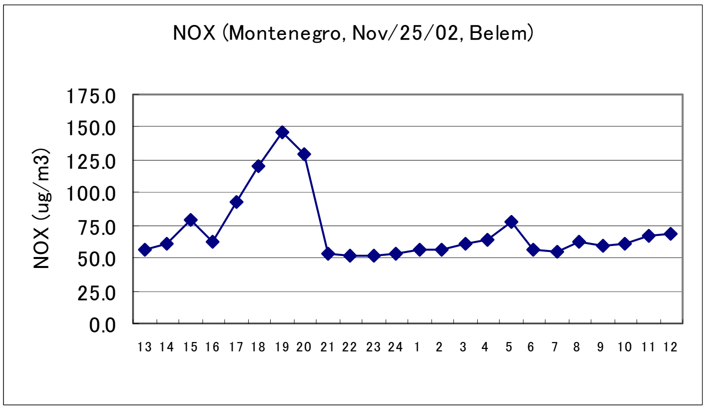


Figure A-20 Roadside A/Q Survey Results (NOX, Augusto Montenegro, Nov/25/02)

(2) Air Quality Survey Results (CO)

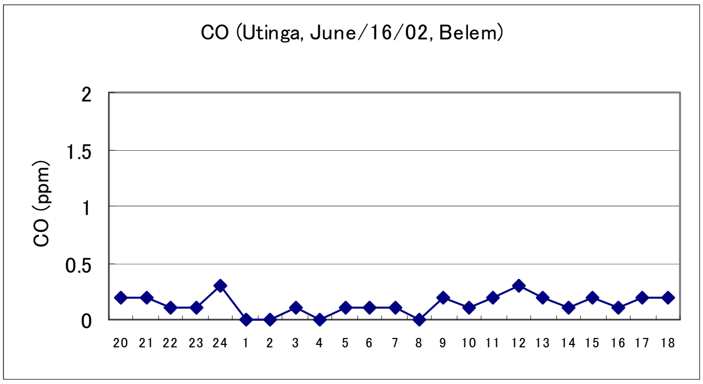


Figure A-21 Roadside A/Q Survey Results (CO, Utinga, June/16/02)

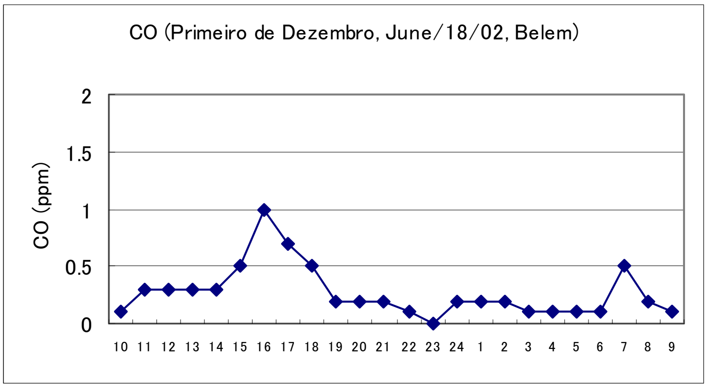


Figure A-22 Roadside A/Q Survey Results (CO, Primeiro de Dezembro, June/18/02)

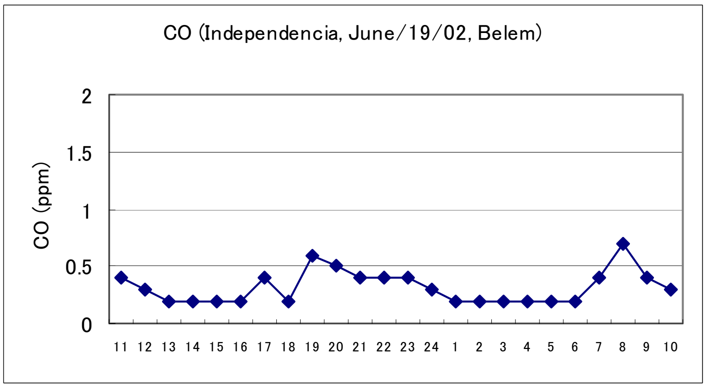


Figure A-23 Roadside A/Q Survey Results (CO, Independencia, June/19/02)

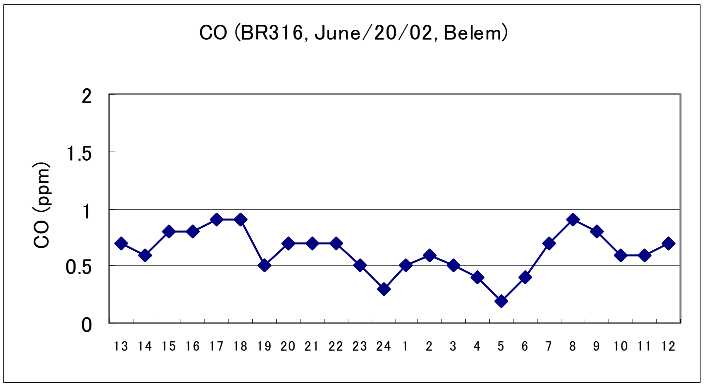


Figure A-24 Roadside A/Q Survey Results (CO, BR316, June/20/02)

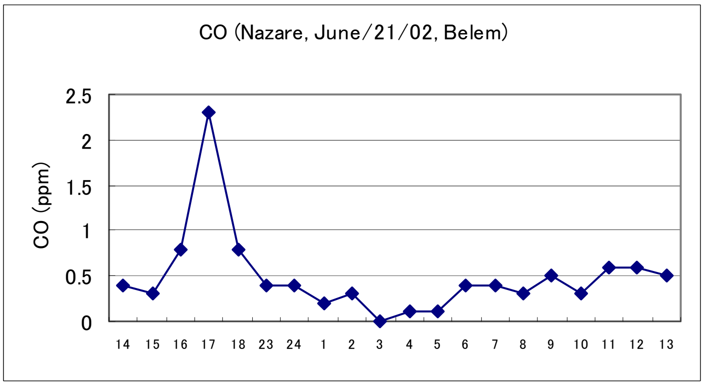


Figure A-25 Roadside A/Q Survey Results (CO, Nazare, June/21/02)

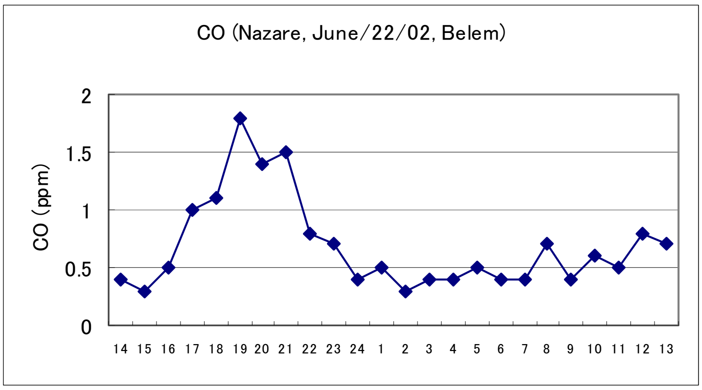


Figure A-26 Roadside A/Q Survey Results (CO, Nazare, June/22/02)

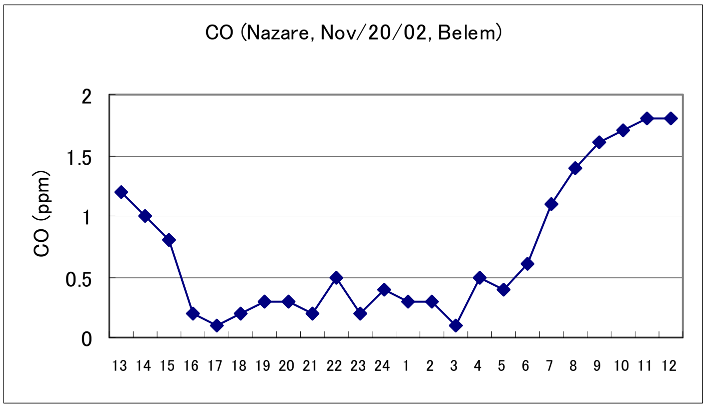


Figure A-27 Roadside A/Q Survey Results (CO, Nazare, Nov/20/02)

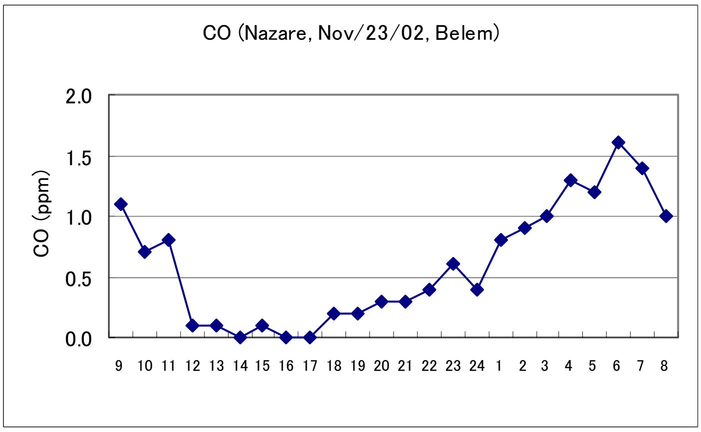


Figure A-28 Roadside A/Q Survey Results (CO, Nazare, Nov/23/02)

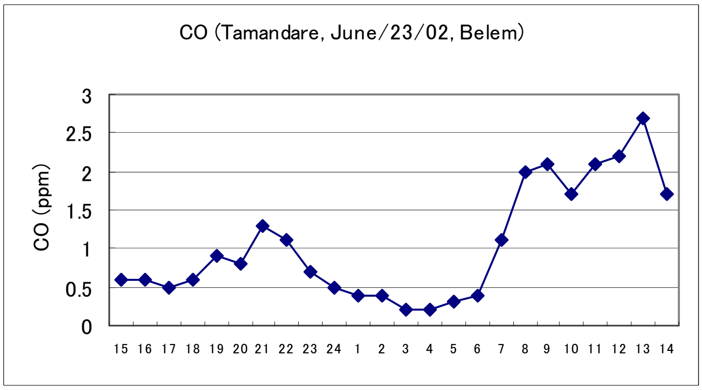


Figure A-29 Roadside A/Q Survey Results (CO, Tamandare, June/23/02)

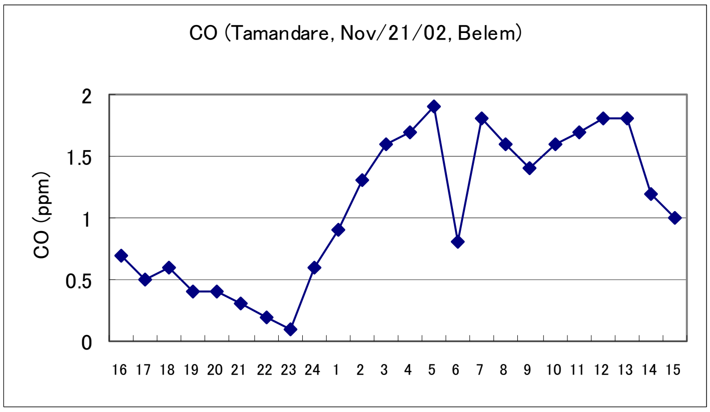


Figure A-30 Roadside A/Q Survey Results (CO, Tamandare, Nov/21/02)

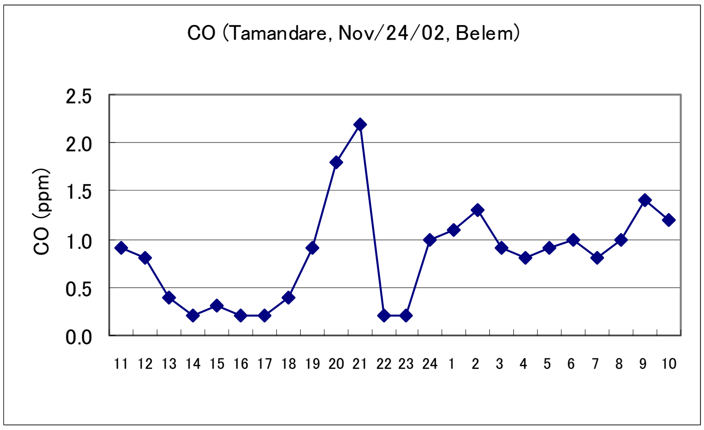


Figure A-31 Roadside A/Q Survey Results (CO, Tamandare, Nov/24/02)

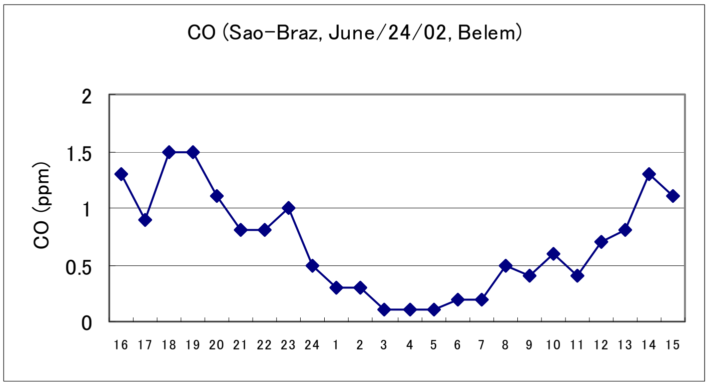


Figure A-32 Roadside A/Q Survey Results (CO, Sao-Braz, June/24/02)

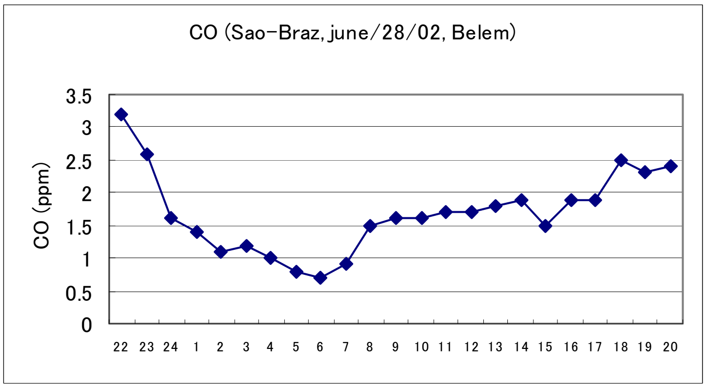


Figure A-33 Roadside A/Q Survey Results (CO, Sao-Braz, June/28/02)

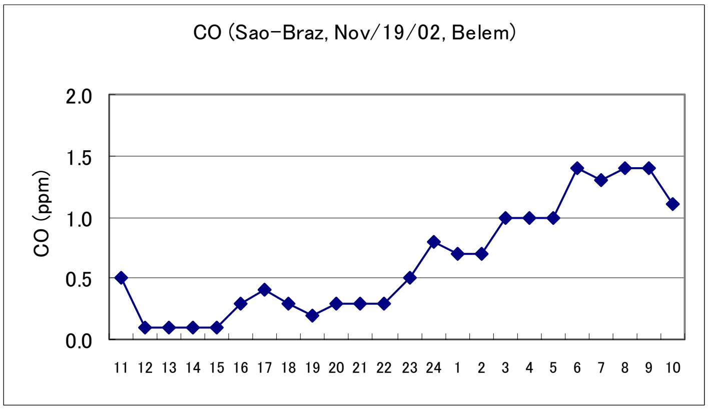


Figure A-34 Roadside A/Q Survey Results (CO, Sao-Braz, Nov/19/02)

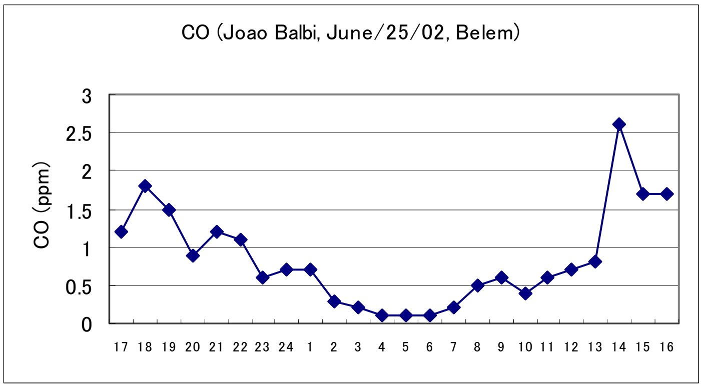


Figure A-35 Roadside A/Q Survey Results (CO, Joao Balbi, June/25/02)

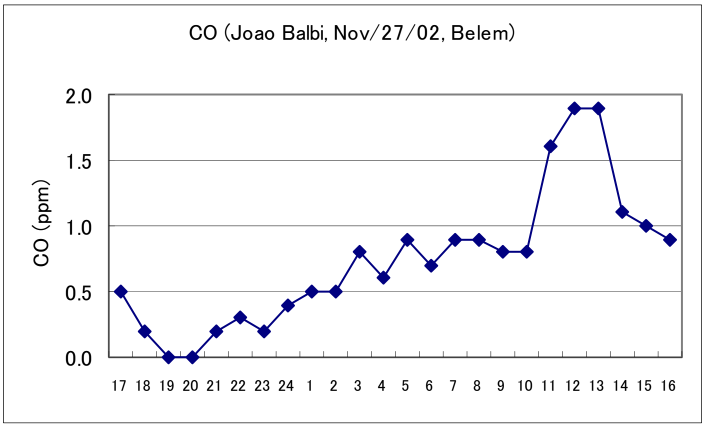


Figure A-36 Roadside A/Q Survey Results (CO, Joao Balbi, Nov/27/02)

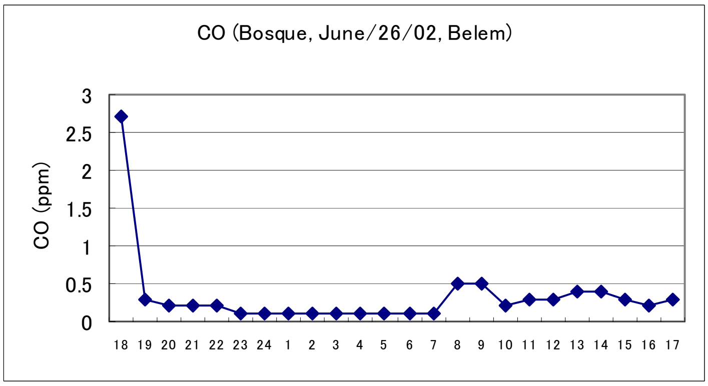


Figure A-37 Roadside A/Q Survey Results (CO, Bosque, June/26/02)

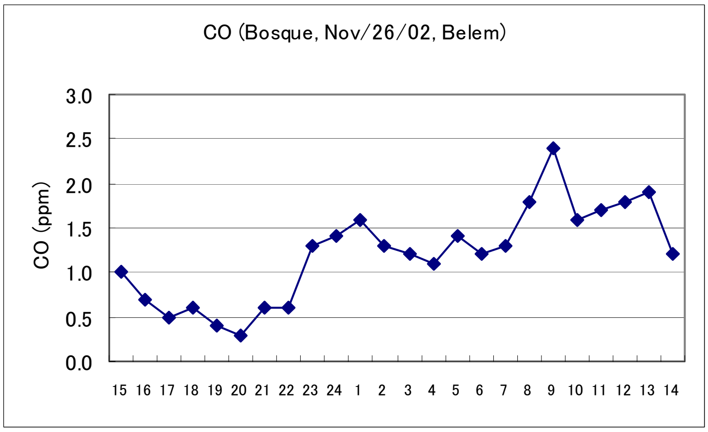


Figure A-38 Roadside A/Q Survey Results (CO, Bosque, Nov/26/02)

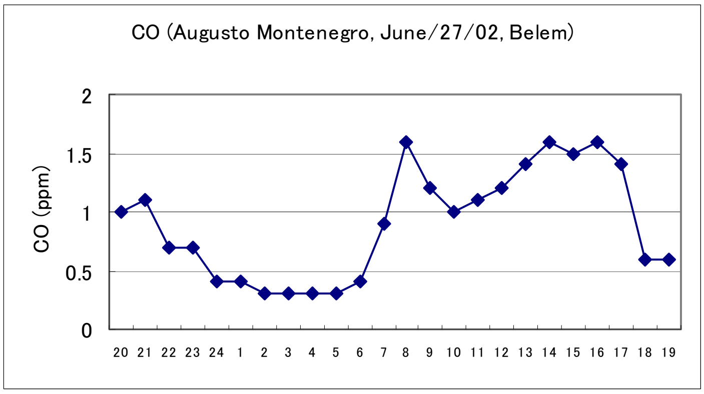


Figure A-39 Roadside A/Q Survey Results (CO, Augusto Montenegro, June/27/02)

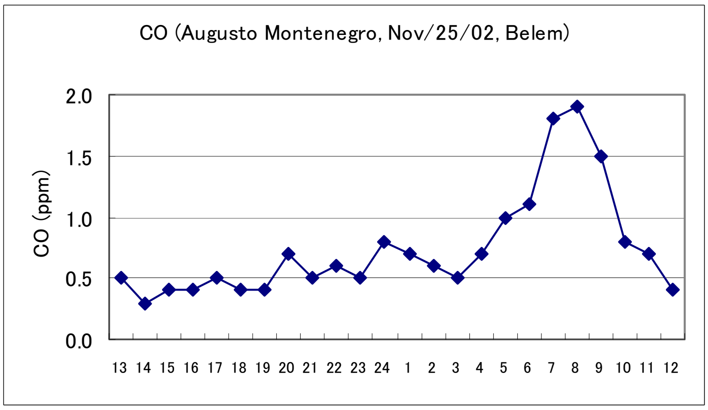


Figure A-40 Roadside A/Q Survey Results (CO, Augusto Montenegro, Nov/25/02)

(3) Noise Survey Results

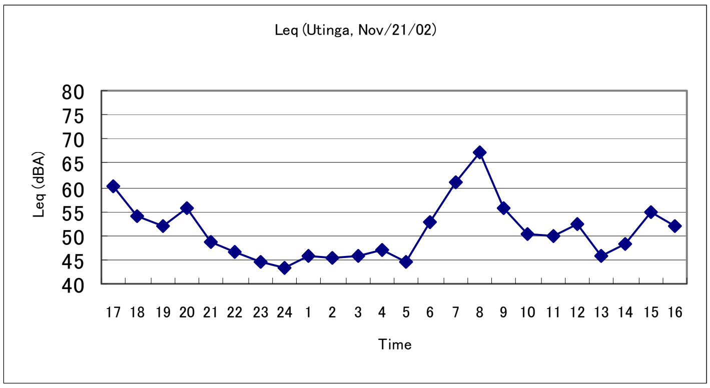


Figure A-41 Noise Measurement Results (Utinga, Nov/21/02)

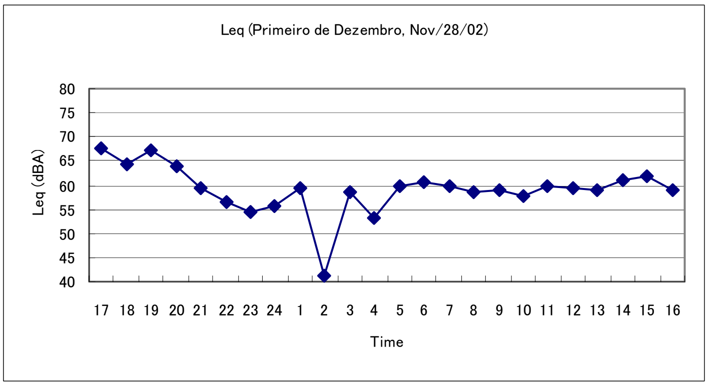


Figure A-42 Noise Measurement Results (Primeiro de Dezembro, Nov/28/02)

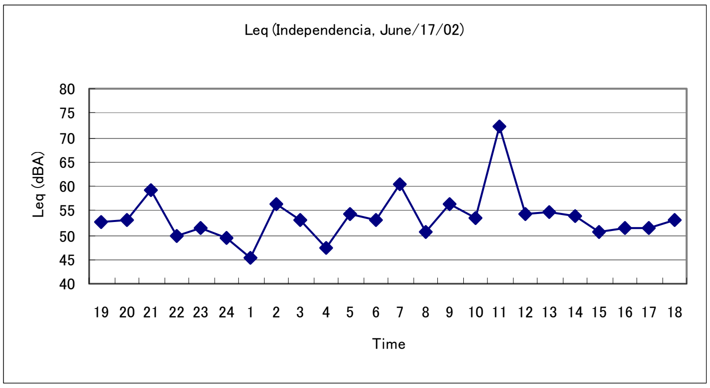


Figure A-43 Noise Measurement Results (Independencia, June/17/02)

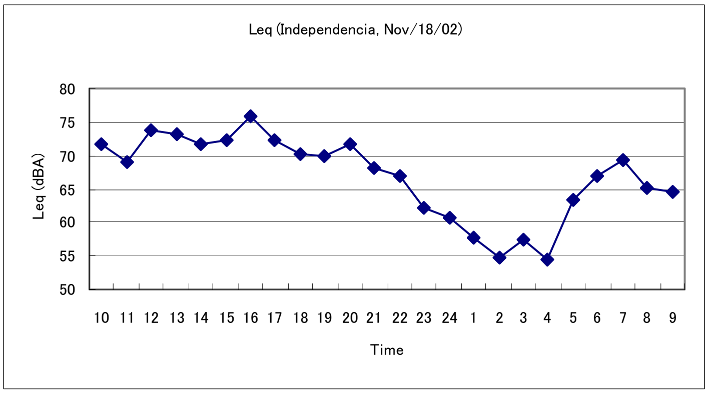


Figure A-44 Noise Measurement Results (Independencia, Nov/18/02)

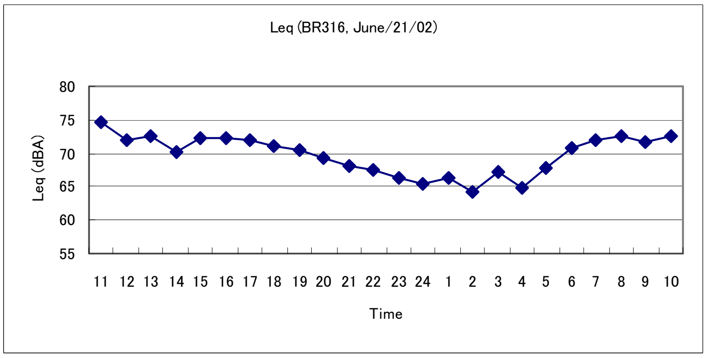


Figure A-45 Noise Measurement Results (BR316, June/21/02)

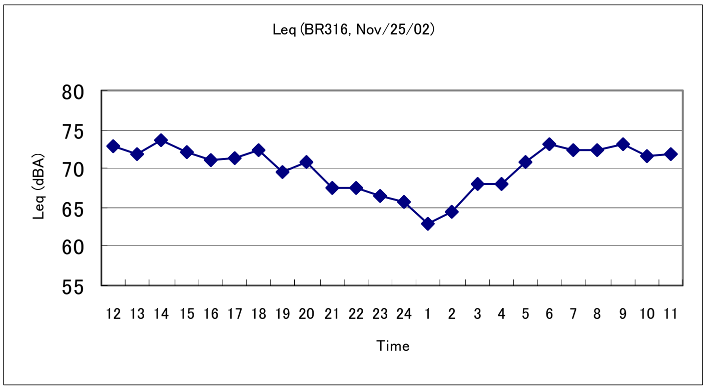


Figure A-46 Noise Measurement Results (BR316, Nov/25/02)

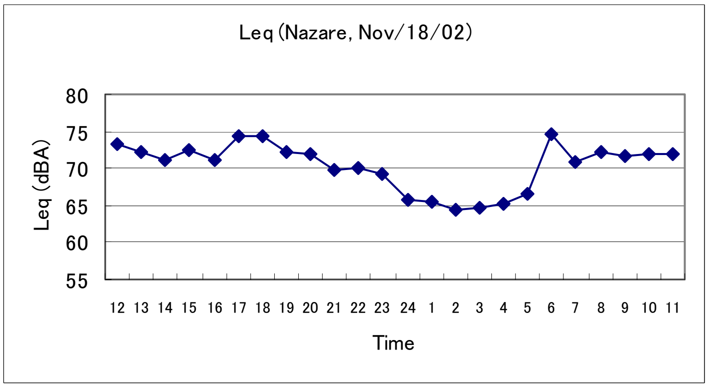


Figure A-47 Noise Measurement Results (Nazare, Nov/18/02)

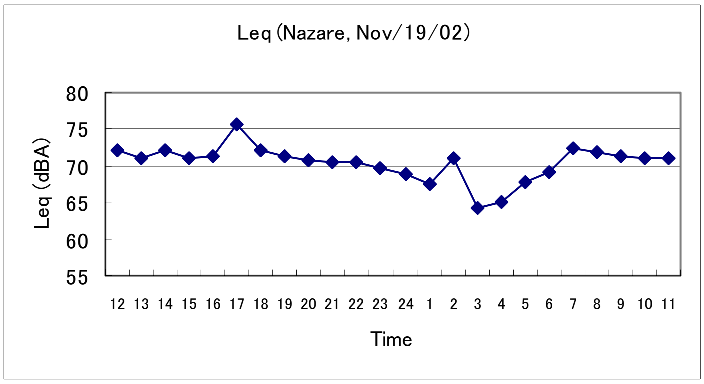


Figure A-48 Noise Measurement Results (Nazare, Nov/19/02)

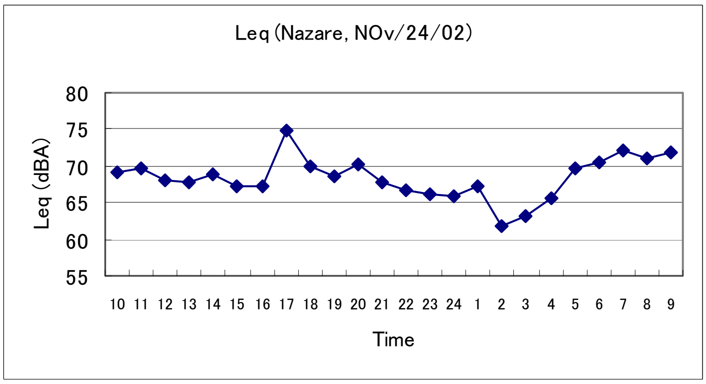


Figure A-49 Noise Measurement Results (Nazare, Nov/24/02)

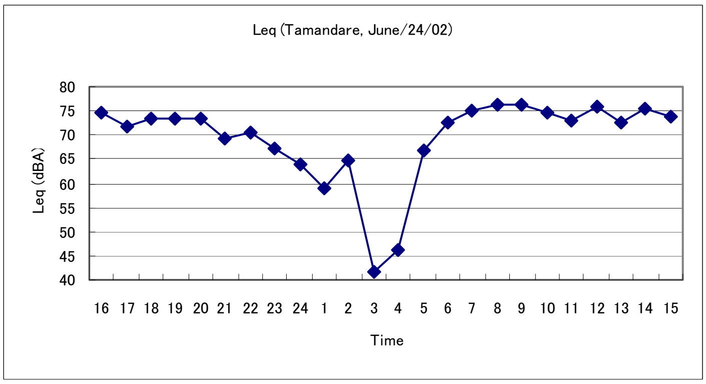


Figure A-50 Noise Measurement Results (Tamandare, June/24/02)

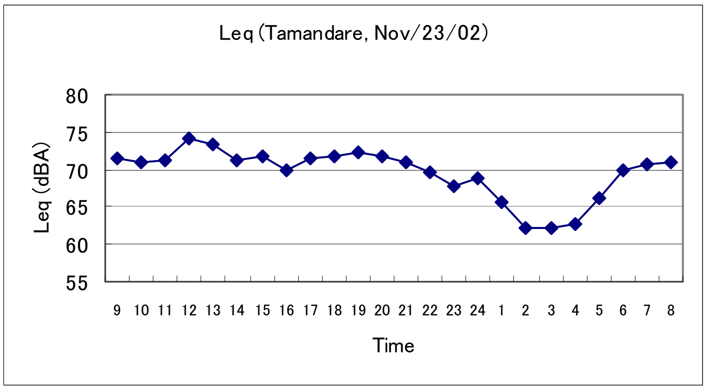


Figure A-51 Noise Measurement Results (Tamandare, Nov/23/02)

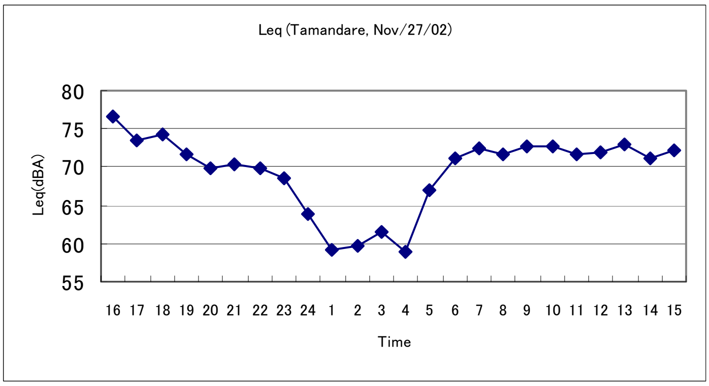


Figure A-52 Noise Measurement Results (Tamandare, Nov/27/02)

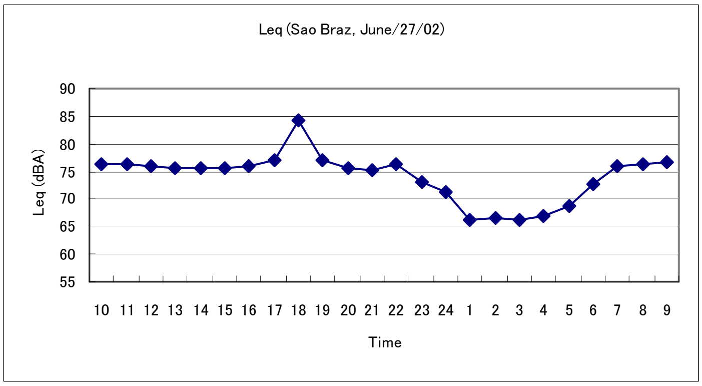


Figure A-53 Noise Measurement Results (Sao Braz, June/27/02)

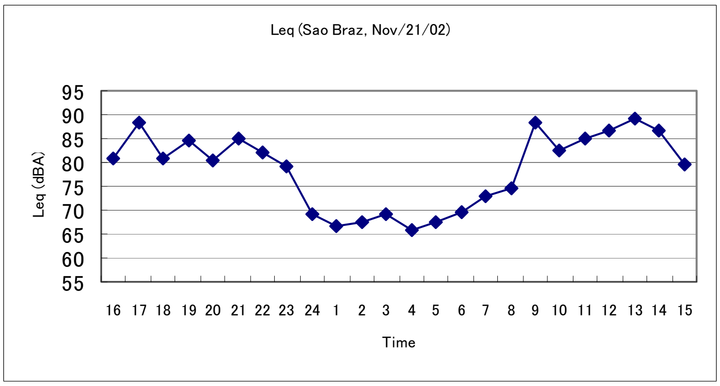


Figure A-54 Noise Measurement Results (Sao Braz, Nov/21/02)

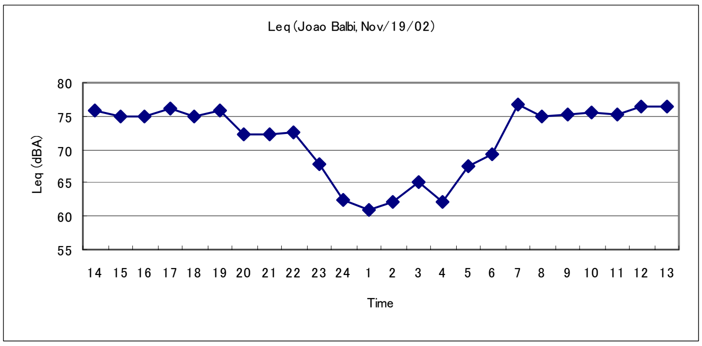


Figure A-55 Noise Measurement Results (Joao Balbi, Nov/19/02)

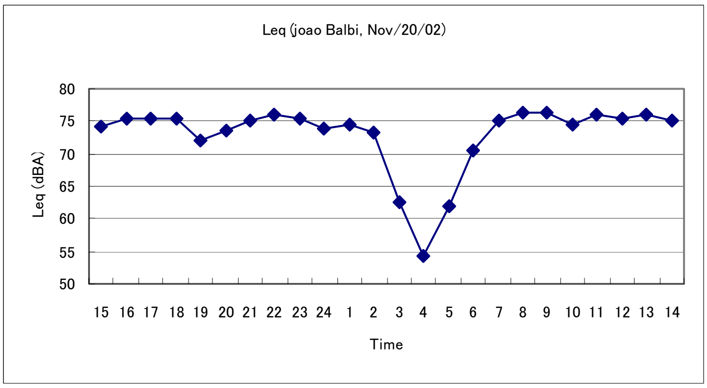


Figure A-56 Noise Measurement Results (Joao Balbi, Nov/20/02)

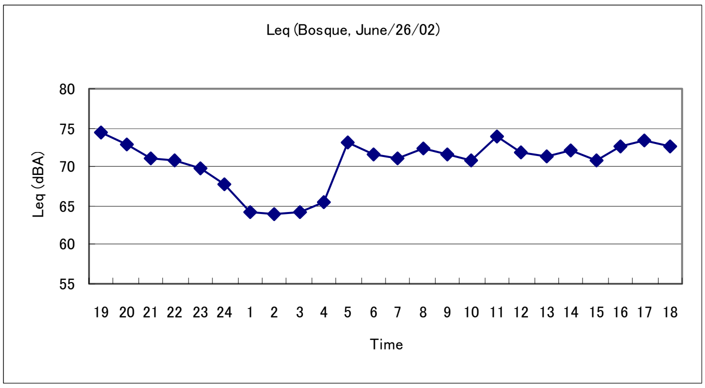


Figure A-57 Noise Measurement Results (Bosque, June/26/02)

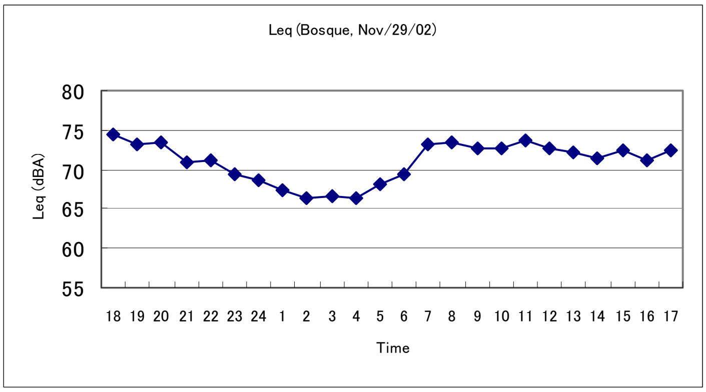


Figure A-58 Noise Measurement Results (Bosque, Nov/29/02)

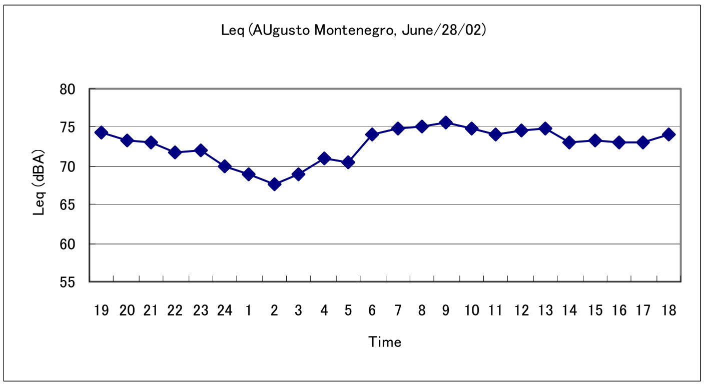


Figure A-59 Noise Measurement Results (Augusto Montenegro, June/28/02)

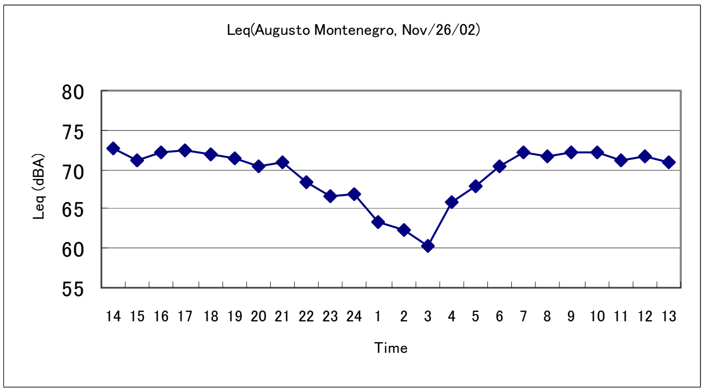


Figure A-60 Noise Measurement Results (Augusto Montenegro, Nov/26/02)

(4) Vibration Survey Results

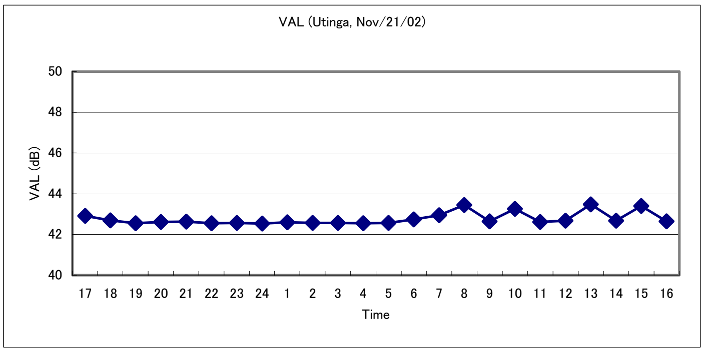


Figure A-61 Vibration Measurement Result (Utinga, Nov/21/02)

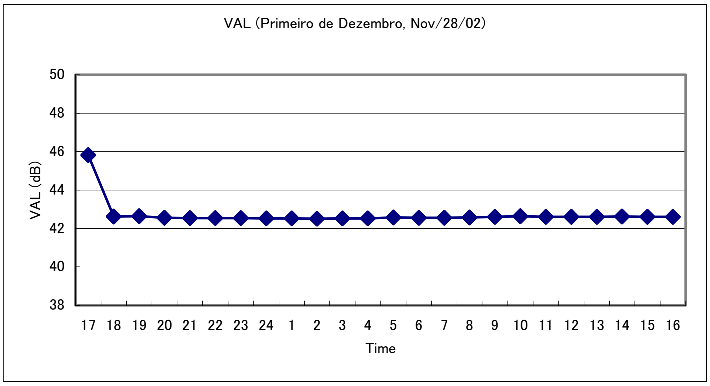


Figure A-62 Vibration Measurement Result (Primeiro de Dezembro, Nov/28/02)

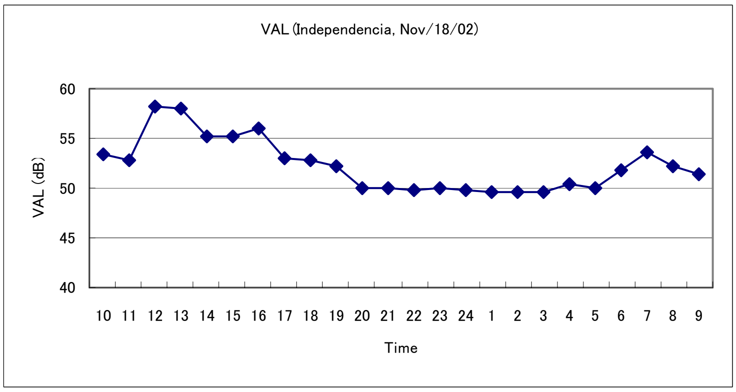


Figure A-63 Vibration Measurement Result (Independencia, Nov/18/02)

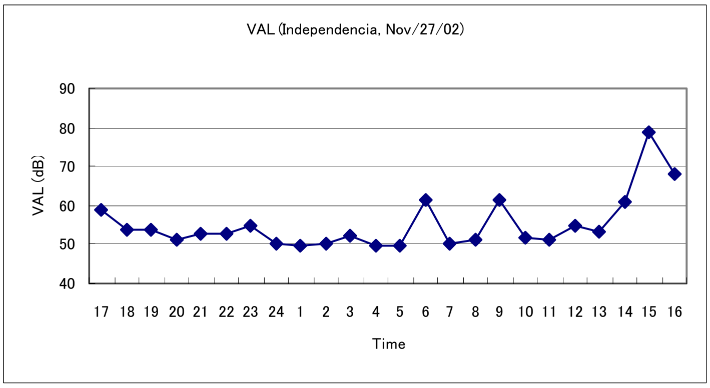


Figure A-64 Vibration Measurement Result (Independencia, Nov/27/02)

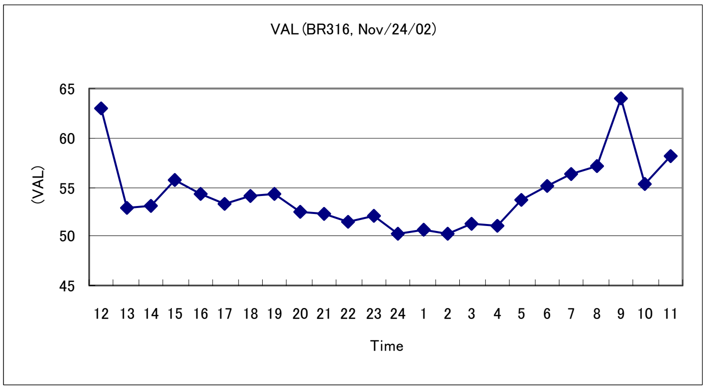


Figure A-65 Vibration Measurement Result (BR316, Nov/24/02)

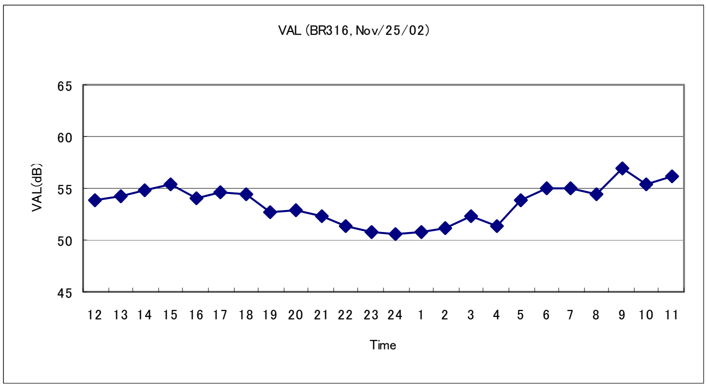


Figure A-66 Vibration Measurement Result (BR316, Nov/25/02)

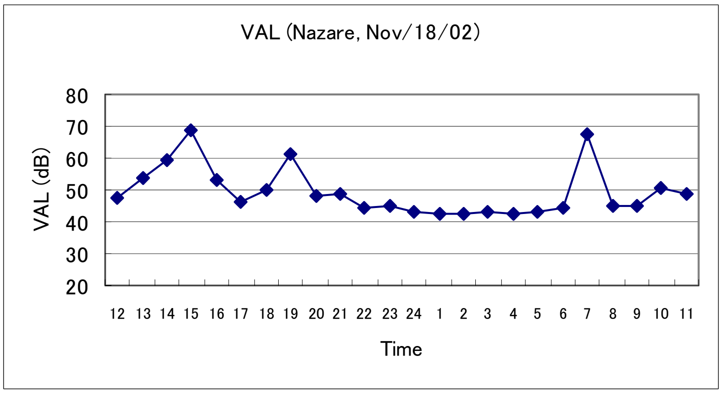


Figure A-67 Vibration Measurement Result (Nazare, Nov/18/02)

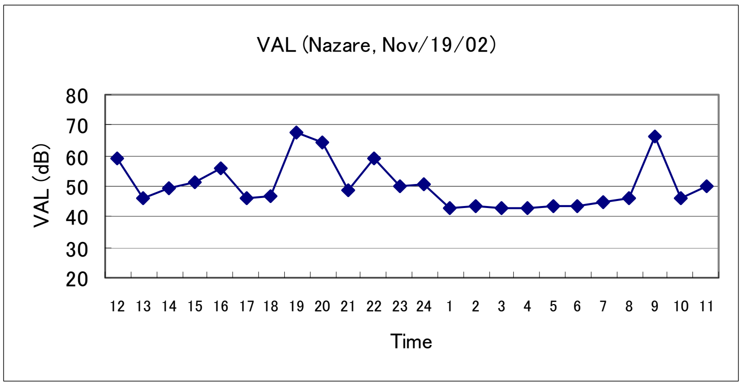


Figure A-68 Vibration Measurement Result (Nazare, Nov/19/02)

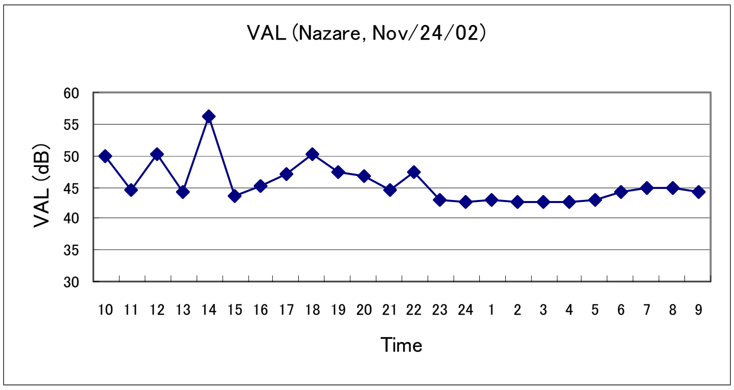


Figure A-69 Vibration Measurement Result (Nazare, Nov/24/02)

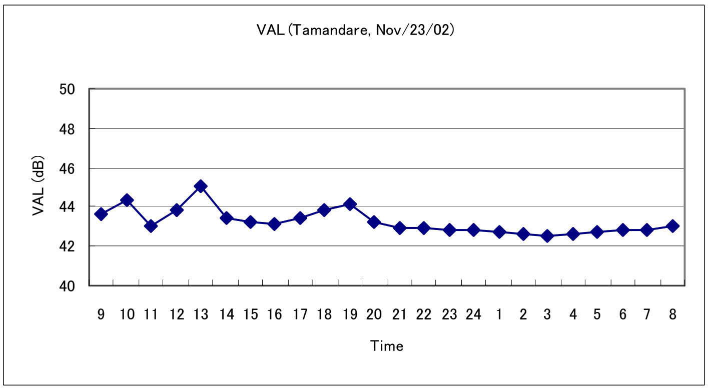


Figure A-70 Vibration Measurement Result (Tamandare, Nov/23/02)

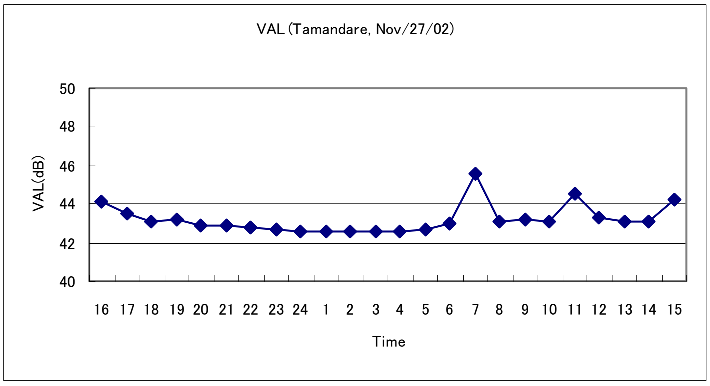


Figure A-71 Vibration Measurement Result (Tamandare, Nov/27/02)

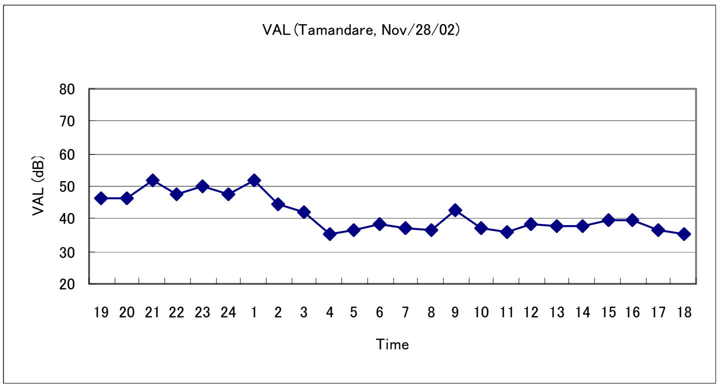


Figure A-72 Vibration Measurement Result (Tamandare, Nov/28/02)

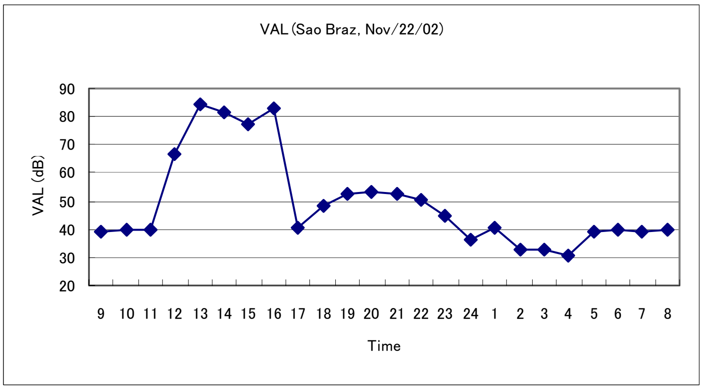


Figure A-73 Vibration Measurement Result (Sao-Braz, Nov/22/02)

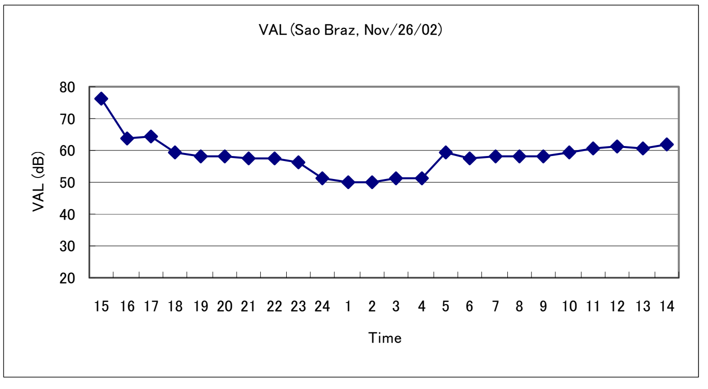


Figure A-74 Vibration Measurement Result (Sao-Braz, Nov/26/02)

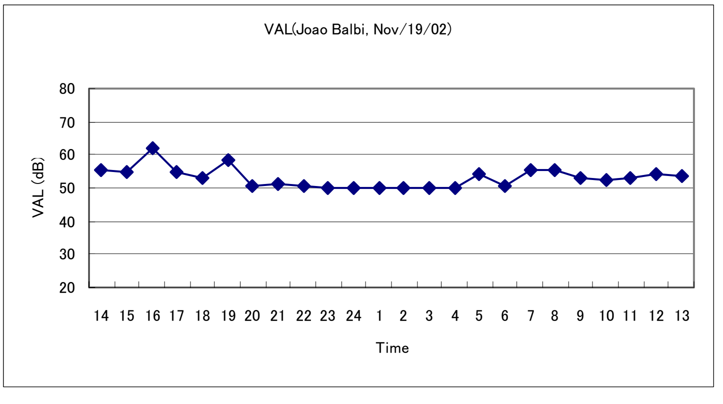


Figure A-75 Vibration Measurement Result (Joao Balbi, Nov/19/02)

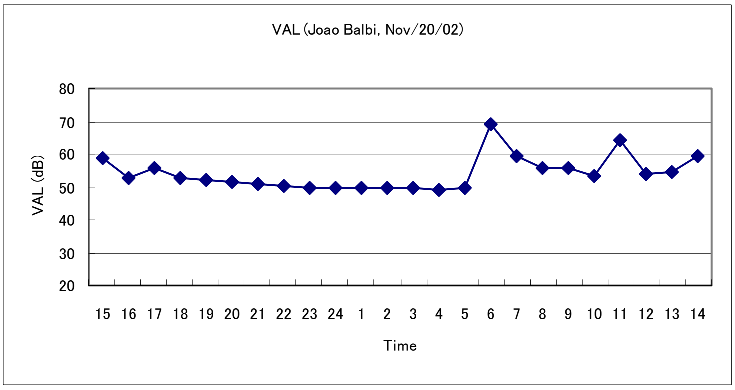


Figure A-76 Vibration Measurement Result (Joao Balbi, Nov/20/02)

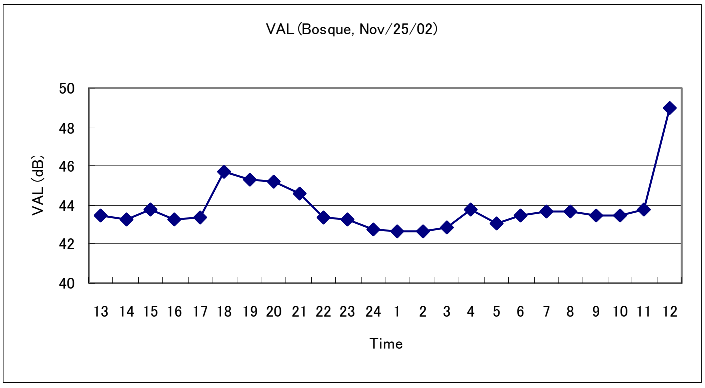
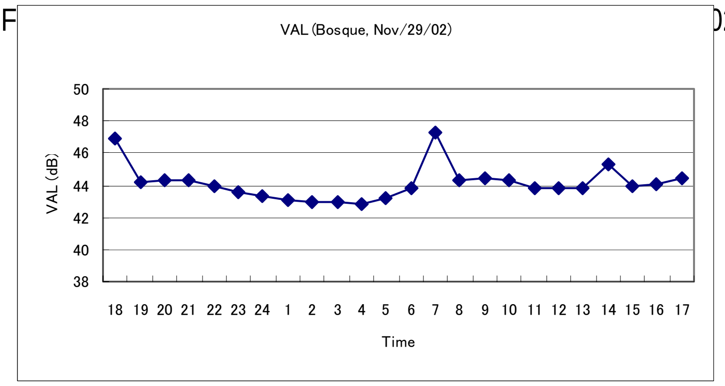


Figure A-77 Vibration Measurement Result (Bosque, Nov/25/02)

F 02)



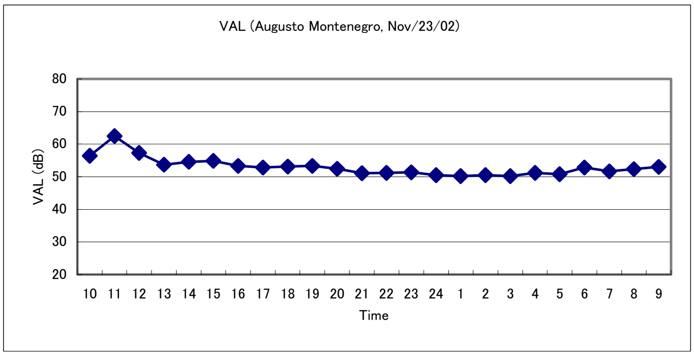


Figure A-79 Vibration Measurement Result (Augusto Montenegro, Nov/23/02)

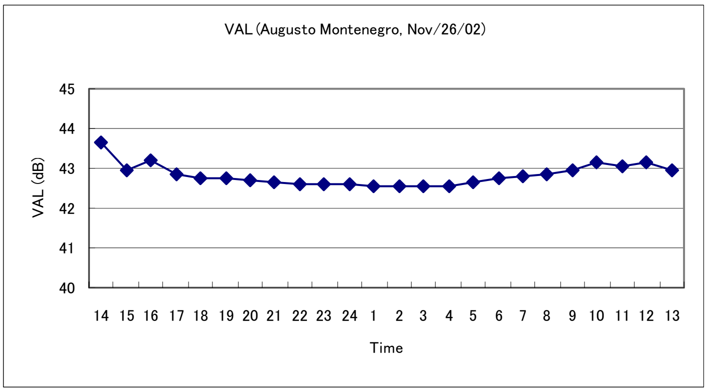


Figure A-80 Vibration Measurement Result (Augusto Montenegro, Nov/26/02)

Appendix A

エラー! 図表目次項目が見つかりません。

Appendix-B
B.11 Trunk Bus Operation Plan

B.11 TRUNK BUS OPERATION PLAN

(1) Electronic Fare Payment Technology

The use of cash in transit fare payment has long been seen as a problem-both for the passengers and the operator, and many agencies have long sought to minimize cash fares in favor of prepaid options. Cash fares can be inconvenient for the passengers, and the need for exact fares often is a barrier to the use of transit.

The introduction of the electronic fare media is useful for effectively operating trunk bus with the decrease of dwelling time at bus stops and bus terminals. There are many issues to introduce the electronic fare media in institutional, technological, and financial aspects. In this section, those issues of the electronic fare media to be introduced in future in the study area are discussed.

1) Current Multipurpose Transit Projects

At present, there are various types of programs developed in oversea, but even many of those examples are still in trial of pilot phases. In the USA, European countries and Japan, development of several multipurpose programs has begun, but in-service applications are of limited scope to date.

shows the range of multipurpose projects involving transit throughout the world. In the USA, there are smart-card-based regional integration projects under development or partially in place. Multipurpose transit projects have been initiated in the United Kingdom, Australia, Korea, Hong Kong, and elsewhere.

Table B-1 Current and Planned Multipurpose Transit Projects

Location	Type of Program	Type of Card	Status (Start Date)	Size of Trial or Program
Newcastle, Australia	M	contact	trial (June 1996)	160 buses
Sydney, Australia	M	contactless	in use	1 million+ cards
Leuven, Belgium	M	contact	in use	terminals on buses
Montreal, Quebec	R	contactless	planned (1997)	integrated system - 3 agencies
Guelph, Ontario	M	contact	trial planned (late 1996)	multiple use (Mondex)
Toronto/Ajax/Burlington, Ontario	R	contactless	trial	bus rtes, 2800 cards (Ajax); plan for comm. rail
Copenhagen, Den.	M	contact	trial (late 1995)	18 TVM's at rail stations
Chambery, France	M	contactless	1 yr. trial (early 1995)	2000 student cards
Valenciennes, France	M,R	dual*	trial planned (Fall 1996)	French Railroad and buses, multiple use planned
Marseilles, France	M	contactless	trial (1994)	(E..C.GAUDI program)
Munich/Frankfurt/Hamburg, German	M,R	contact	trial (1996)	telephone/rail/bus card (“Paycard”)
Hong Kong	R	contactless	trial (1996)	20,000 cards, plan for 3 million cards (by 1997)
Dublin, Ireland	M	contact	3-mo.trial (Feb.94)	25 buses, 2000 cards
Rotterdam, Netherlands	M	contact	trial (1997)	regional transit (PTT/Postbank Chipper)
Oslo, Norway	R,T	contactless	trial planned (early 95)	1200 bus, 108 LRT,69 rail
Seoul, S. Korea	M,R	contactless	in use (Feb.1996)	8700 buses, 1.2 million cards, plan for multi-use
Biel, Switzerland	M	contact	in use (3+ yrs.)	30,000 cards
Manchester, UK	M	contactless	full use by 1997	5000 cards,2700 bus
Phoenix, AZ	M	magnetic	in use (May 1995)	(accept credit cards on bus)
Culver City, Foothill, Montebello, CA	R	magnetic	in use (March 1994)	280 buses (Metrocard)
San Francisco, CA	R	contactless	trial planned (1997)	26 transit agencies
Ventura Co., CA	R	contactless	in use (March 1996)	7 agencies, 3500 cards
Washington, DC	T	contactless	1 Yr. trial (Dec.94)	19 stations,22 buses, 5 pkg lots, 1000 cards
Wilmington, DC	M	contact	trial planned (on hold)	150 buses (Wilmington Trust-SmartCash)
Atlanta, GA	M	contact	trial (May 1996)	33 rail stations (3 banks - VISA Cash)
Ann Arbor, MI	M	contact	trial planned (1996)	80 buses; 35000 campus cards
New York, NY	M,R,T	TBD	planned (on hold)	(plan for multiple use)
Cleveland, OH	M	dual*	trial planned (1997)	bus/rail & other (bank, retail, campus, etc.)
Seattle, WA	R	contactless	trial planned (1996)	5 transit agencies, ferry

* contact & contactless
NA=data not available
TBD=to be determined

Type of Program: R=regional Integaration
T=transit and parking or tolls
M=multiple use

Source: the Report of “Multipurpose Fare Media”, June 1997, Transit Cooperative Research Program sponsored by the Federal Transit Administration

2) *Electronic transit fare media*

Multipurpose transit fare media can take three basic forms:

- Multiple-use media that can be used in several applications (e.g., transit, retail purchases, banking);
- Integrated regional fare media that can be used on multiple transit agencies in an area (i.e., a "universal ticket"); and
- Integrated fare media that can be used in transit as well as other transportation modes (e.g., parking, tolls).

The multiple-use media is the most advanced system. The integrated fare media will be preferred to introduce into the trunk bus system in future in the study area. Those medias use electronic purse cards, which contain more functions such as identification and information.

3) *Basic Institutional Approach*

One of the fundamental issues is whether a multipurpose card issued and used in an **open or closed system (transportation only)**.

- **An open system** is one in which there are multiple card issuers and multiple service providers (for instance, credit and debit cards operate in an open system).
- **A closed system** is one in which the card is issued by a single entity and can be used only for that entity's service; transit fare payment has traditionally operated in a closed system.

In the closed system, a transportation agency issues fare media usable on any of the agency's service. One or more of the member agencies can provide card production and distribution, revenue reconciliation and settlement, equipment procurement, and maintenance. The closed system is an expansion of the current fare collection system at every transportation agency to incorporate neighboring transit service.

Figure B-1 shows the typical closed payment system.

On the other hand, the transportation agencies accept media from multiple issues in an open system. There are several possible models for a transportation agency's participation in the open system. One is that the transportation agency becomes a participating "entity" in a general electronic-purse and stored-value card program. In this case, the transportation agency does not issue cards itself. The second is that the agency becomes a formal partner in the arrangement, sharing both the benefits and the financial risk. The transportation agency may be one of multiple card issuers. The last is that the agency (or consortium) administers its own payment program, but allows outside issuers' card, and the agency issues cards. Figure B-2 shows the typical open payment system.

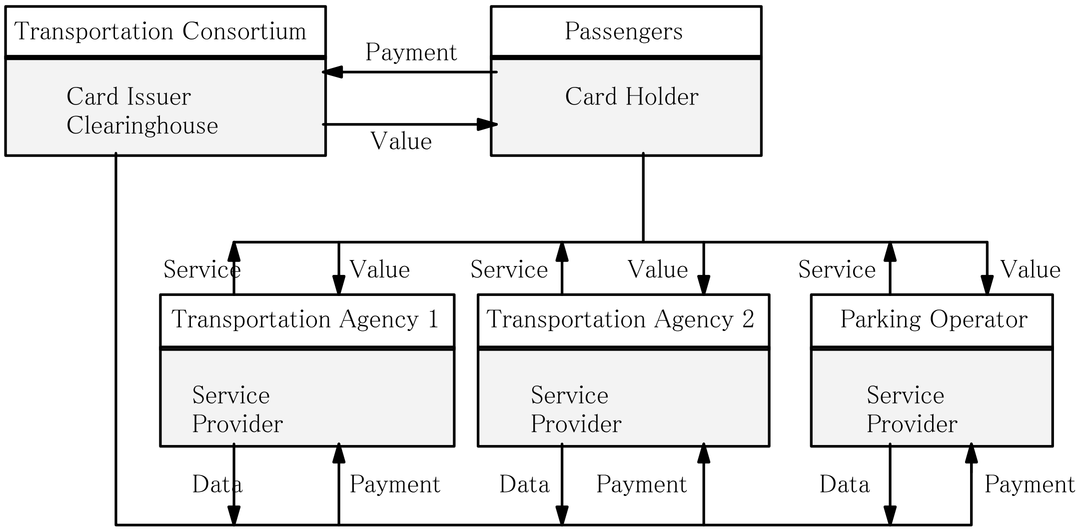
The relative advantages are summarized in Table B-2.

Table B-2 Closed versus Open System: relative Advantages for Transportation agencies

Area	Closed	Open
Financial effect	- Retain all additional revenues - Lower exposure to fraud	- Reduced fare collection costs - Limited financial risk
Degree of control and	Retain authority over all fare	Reduced responsibility (e.g.,

administrative responsibility	collection functions	for distribution and settlement)
Appeal to customers and pricing flexibility	Greater flexibility in pricing (e.g., setting discounts or bonuses)	Greater appeal to customers: more flexible card and wider distribution

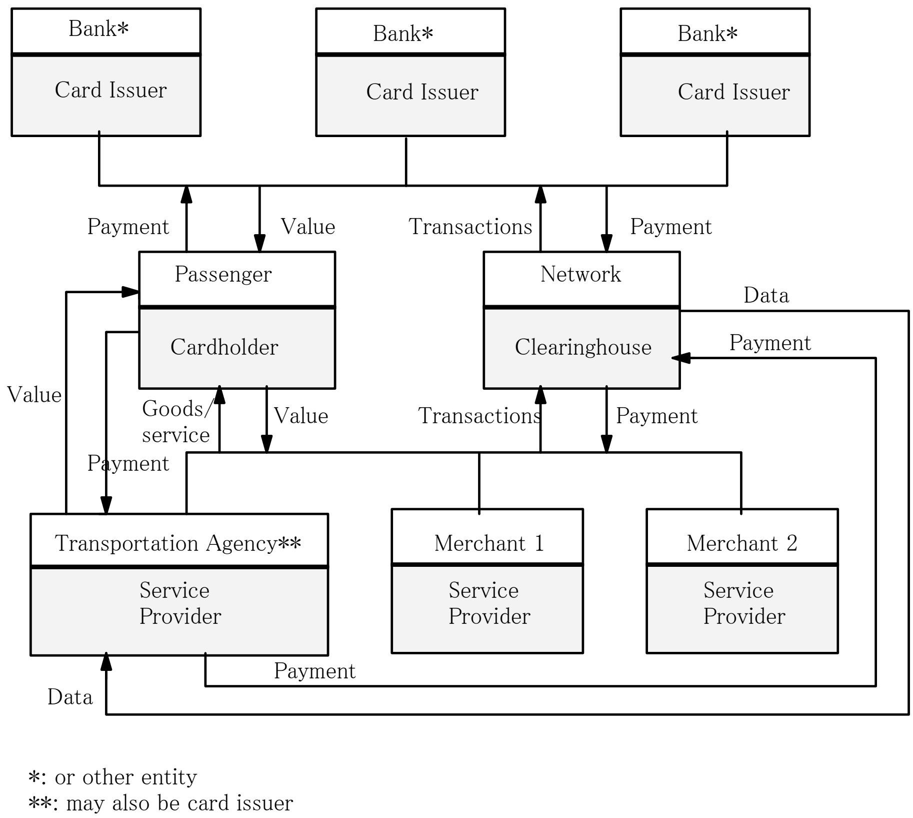
Source: the Report of "Multipurpose Fare Media", June 1997, Transit Cooperative Research Program sponsored by the Federal Transit Administration



Source: the Report of "Multipurpose Fare Media", June 1997, Transit Cooperative Research Program sponsored by the Federal Transit Administration

Clearinghouse-an entity or organization responsible for managing many of the support functions for the multipurpose program, including card management (e.g., issuance and distribution), revenue management (e.g., collection, reconciliation, and settlement), customer service, and marketing.

Figure B-1 Closed (Transportation only, Multi-operator) Payment System



Merchant: an entity (e.g., a transportation agency or a retailer) that will accept the media as payment for the provision of a service or a product.

Source: the Report of "Multipurpose Fare Media", June 1997, Transit Cooperative Research Program sponsored by the Federal Transit Administration

Figure B-2 Open Payment System

4) Card Technology

The electronic fare payment technology recently offers transit operations a new type of fare media. This technology, particularly the development of integrated-circuit (**smart**) cards has created opportunities to use at multiple transit agencies within an area (i.e., integrated ticket) and for other transportation modes (e.g., parking and tolls). The use of magnetic-stripe media can allow integration of payments with other transit agencies. Although the use of magnetic-stripe media is increasing in the transportation industry, the application of electronic payment media has shifted from the magnetic-strip media to smart cards in the integrated fare program. The advantages of smart cards over magnetic-stripe media are as follows.

- The higher expected reliability of smart cards and the supporting equipment
- The greater data and processing capabilities of smart cards
- The move toward adoption of smart cards by the banking and financial services

Technically, a smart card has an onboard microprocessor and built-in logic. There are two major classifications of smart cards: **contact and contactless cards**.

- Contact cards require a physical contact between the card and the read-write unit, and must be inserted into a slot.

- Contactless cards do not have to be inserted into a slot, but rather can be ready by passing the card close to the read-write unit.

One type of hybrid card combines a smart card with a magneticstripe, while a newer option (better known as a **combi-card** or **dual-interface card**) combines the attributes of contact and contactless cards- either using two separate chips or a single chip capable.

The advantages of contactless card systems for transit agencies are as follows:

- Potential for lower fare collection equipment maintenance costs, because there are no moving parts in the read-write units
- Greater reliability of equipment, because there are no open slot that can be jammed
- Greater convenience for passengers, especially for elderly or disabled passengers who may have difficulty inserting a card
- Faster boarding of buses and entry through turnstiles

In general, the key concerns in choosing a particular type of media or equipment for a multipurpose program may include the following factors.

- The agency's fare media needs and fare collection goals
- System costs and the funding available
- The technology to be used by other entities

5) Issues and Concerns

The development of electronic card system will require a fundamental change, which applies to the customer (bus passengers), the transit agency, and the financial institution.

- **Institutional**: who are the participants in the program, how is the program organized and operated, and what are the legal and regulatory requirements that must be addressed?
- **Technological**: what types card will form the basis for the program, what are the design requirements, how will the new technology be integrated into the existing system?
- **Financial**: what are the expected costs and benefits of the program to each potential participant?
- **Customer-Related**: to what extent will customers participate in the program, and how will their concerns be addressed (e.g., related to privacy)?

As the transportation companies in Brazil are beginning to recognize the benefits of the electronic fare payment media in facilitating such fare integration, the issues in institutional, technological, financial and customer-related aspects have to be discussed with related agencies for the introduction of the program into the trunk bus system operated in 2007.

6) Present conditions of Fare collection system in the USA

The following shows the results of a survey of transit agencies conducted in the USA, which refer to the Report of "Multipurpose Fare Media", June 1997, Transit Cooperative Research Program sponsored by the Federal Transit Administration. The focus of the survey was on current fare collection practices and costs, plans for use of emerging technologies, agency goals for improving fare collection systems, and issues and concerns regarding possible multiple-use payment arrangements. 86 transport agencies included rapid rail, commuter rail, or light rail service and bus-only system (i.e., bus-only transportation), were surveyed.

A. Present Fare Collection System

Under the multiple responses, cash (98%), tokens (50%), and magnetic-stripe cards (35%) are predominant. Smart card (6%) and Debit cards (9%) are few percentages.

B. Existing Fare Collection Equipment

Electronic registering fareboxes (83%) are the most widely used pieces of fare collection equipment. Magnetic-card swipe readers are the next most widely used with 33%. Nonregistering fareboxes are used by only 29% of the agencies.

C. Plan for New Fare Collection System

A magneticstripe, stored-value card technology was the most often cited with 71%. Contactless and contact smart-card technologies are expected to be implemented by 34% and 29% of the respondents, respectively.

D. Fare System Cost

A percentage of "Production and distribution costs" to total fare revenue is approximately 1% for bus-only system (bus companies). As for "Collection and Processing" costs, bus-only system responded at 1.9% of total fare revenue.

E. Goal for Improving Fare System

The following are the five goals by bus-only system.

- Improve the convenience for passengers
- Improve the ability to collect needed data (e.g., origin and destination data)
- Improve the ease of administrating fare collection by bus operators and other personnel
- Improve the ability to integrate with other onboard technologies (e.g., automated vehicle location (AVL) or automated passenger counter)
- Improve card read-write unit reliability.

F. Issues and Concerns related to Potential Multiple-Use Arrangement

The following list presents the issues by bus-only system in order of overall importance:

- Institutional issues (e.g., maintaining control over the fare system, including the ability to modify fare structures)
- Cost of providing electronic fare media and of participating in a multiple transit use or joint banking and transit program
- Card technology issues (e.g., the need to accept technology selected by other agencies)
- Privacy issues for passengers
- **Clearinghouse**/settlement issues (e.g., related to apportioning revenues among participating agencies)
- Legal and regulatory issues (e.g., constraints on an agency's ability to enter into agreements with other entities)

(2) Automated Vehicle Location System (AVL System)

1) Outline of AVL System

Bus transportation agencies are turning to advanced technologies to improve service, increase safety, and attract ridership. Specially, automatic vehicle monitoring (AVM) systems are being developed on bus transport to achieve operational system benefits. Although AVM systems were deployed in the 1970s and 1980s, only recently have transit agencies embraced the concept. The core technology, the automatic vehicle location (AVL) system, offers detailed status information previously absent from the bus operations, customer support, maintenance, and service planning areas.

The AVL system tracks vehicle movement. This capability, integrated with other functions, enables transit agencies to provide new and improved services, such as reduced emergency response time, real-time bus status information, automated passenger counting information, and improved mobile communications.

The AVL component complements system that:

1) Measure system performance, ridership, and schedule adherence
2) Provide estimated time of arrival
3) Announce next stop information
4) Display vehicles on an electronic map

As an automated technology, AVL collects, processes, and communicates location information to other applications that need accurate and timely location data.

The AVL component is integrated with or contributes to system such as,

- Emergency location of vehicles
- Fleet management including vehicle performance monitoring and service control
- Data collection
- Fare collection
- Traffic signal priority

This synthesis examines the range of implementations, benefit, and institutional issues associated with operating AVL systems for fixed-route bus transit.

2) AVL Technologies

AVL is an enabling technology for many operational tasks but only a few benefits can be derived from AVL alone. Additional software, hardware, and communications components need to be in place to measure performance, quality of service, and effectiveness of schedules and routes, to ensure safety of operators and passengers, and to provide current service status information to travelers.

Many vendors break down AVL systems into their function subsystems: onboard, communications, and central control system. The navigation and communication systems are composed of both onboard and infrastructure devices. Most navigation systems use radio frequency (RF) to communicate. These units, located onboard a vehicle, receive and send signals from/to infrastructure devices such as roadway beacons, radio towers, and satellites.

The navigation system consists of the equipment and software that identify the location of the vehicle. Navigation technologies may be divided into three general categories.

- Radio navigation
- Dead reckoning
- Other tracking technologies

Radio navigation systems are defined as any location technology that relies on a radio signal to determine position. Among the technologies in this category are global positioning system (GPS), satellite and radio triangulation, signpost, and wayside transponders. Dead-reckoning sensors use direction/hearing and distance/speed to determine relative location from a fixed point. Compasses, odometers, and internal platforms are all dead reckoning sensors.

All radio navigation system require onboard and infrastructure devices. With a beacon system, the receiver/transmitter location is known, so when the vehicle travelers within its signal coverage. Signposts and wayside transponders are types of beacon system.

Most of the early developments used a combination of signpost and dead-reckoning navigational technologies, although many of these early systems were beset with procurement and technology problems. In the 1990s radio-navigation methods such as Loran-C and GPS satellites looked promising. As costs for GPS receivers declined, GPS has become the most popular technology for AVL applications.

Signpost

Most early AVL development projects used signpost technology as the location sensor. A signpost system may be composed of an onboard short-range communication device and an infrastructure mounted beacon. Existing signpost systems work in two modes:

Mode 1: A vehicle with a transponder continuously sending a signal.

Mode 2: The signpost continually broadcasts its identification number.

Since the location of each signpost and its signal coverage are known, the positional accuracy can be determined.

3) Bus Navigation Service by GPS in Japan

Recently, in Japan bus agencies and bus companies have implemented the AVL system to improve bus transit operations, reliability, increased safety, and better performance. Among them, bus navigation service by GPS technology is introduced here.

Tokyu Bus Corporation serves bus operation in Tokyo with bus navigation service by using GPS technology. The functional outline of the system is as follows.

1) Information of all bus position
   - The position information on all the buses that run on bus line is seen on the screen.
2) Bus approach information and necessary time information
   - You can see mark  that a bus approaches the bus stop.
   - It shows how long the bus that approaches takes to get to the bus stop.
   - The time requirement between each bus stop is shown from the bus stop to a terminal points.
3) Time table information
   - Time table of a bus stop is shown according to Weekdays, Saturdays and Sundays
4) Operation management information

- Bus position information (Bus ID numbers, Bus Line numbers and Driver's name) and road traffic information are displayed on the computers of a bus office and operation management is performed. Figure B-4 shows the screen of operation situation on the display at the bus office.

Figure B-3 shows a structure of the whole system in Tokyu Bus Corporation. Each bus information is transmitted with NTT DoCoMo (Japanese communication company) Packet communications. The information sends to Tokyu Bus Service Center through the NEC Operation Center (private company). Bus users access to the Internet to obtain the necessary bus information.

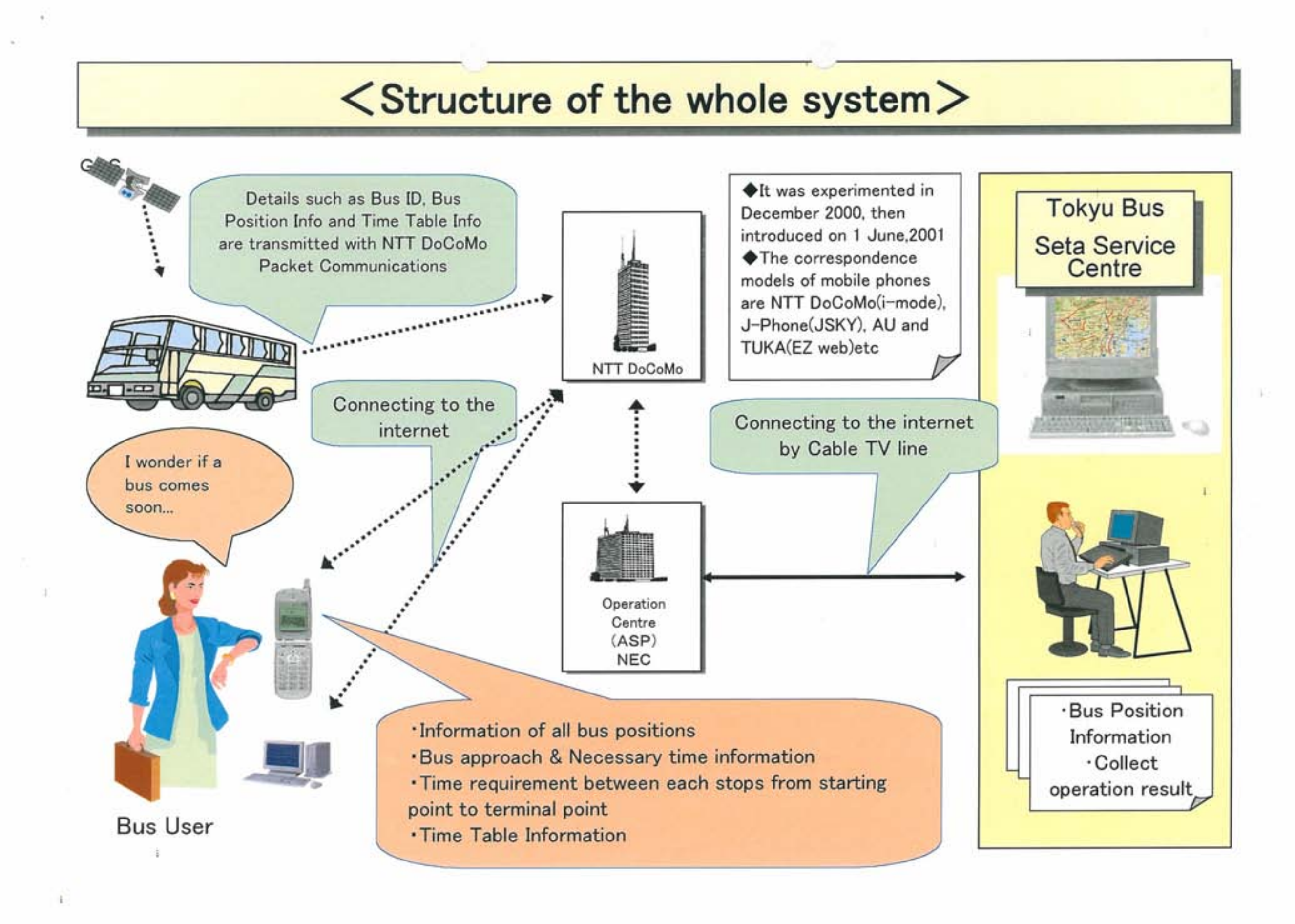


Figure B-3 Structure of the Whole System

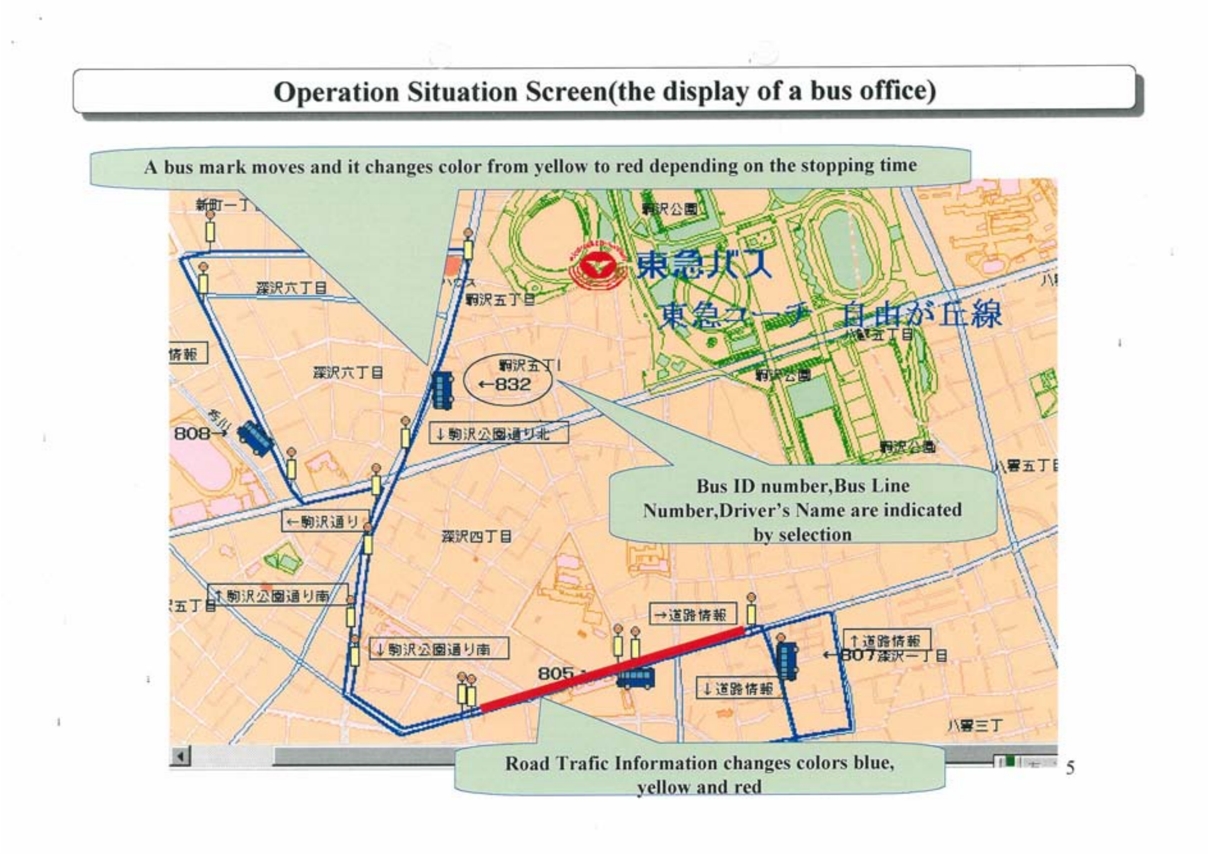


Figure B-4 Operation Situation Screen (the Display of a Bus Office)

Figure B-5 shows the structure of the equipment on the bus. The system, which joins in Voice Synthesis Guidance Equipment (AGS), is adopted. All the information such as bus routes, directions, and bus stops are transmitted with Packet Communication System from Voice Synthesis Broadcast Equipment on the buses. When information cannot be transmitted, the position information is automatically sent by GPS.

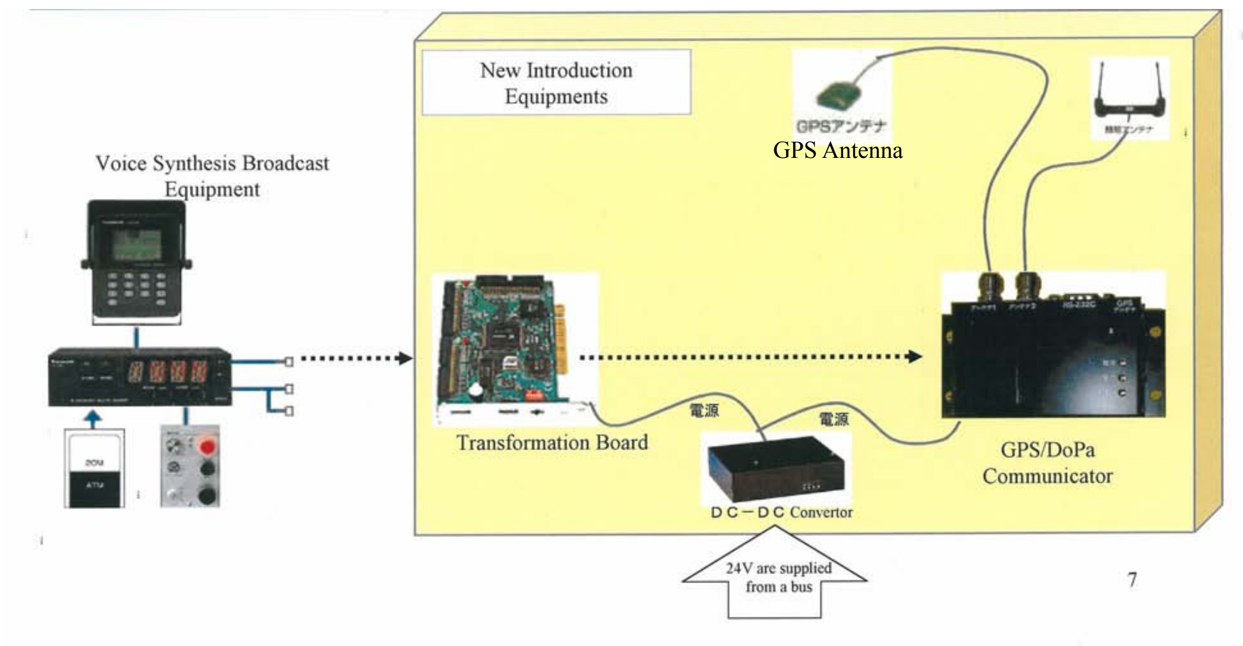


Figure B-5 Structure of the Equipment on the Bus

Appendix-C
C.16 Construction Planning And Cost Estimate

C.16 CONSTRUCTION PLANNING AND COST ESTIMATE

Table C-1 Unit Direct Cost

Table16- 1 Leveling (common soil)

Construction work	Leveling (common soil)				
Unit of work	1.00 m3				
Work item	Quantity of work	Unit	Uunit-price (R$)	Sub.total (R$)	Remarks
Equipment					
Motor Grader	0.60	hr.	94.03	56.41	
				0.00	
			(A) Total	56.41	
Labor					
Foreman	0.20	hr.	5.22	1.04	
Operator	0.60	hr.	4.81	2.88	
Worker	4.00	hr.	2.31	9.24	
			(B)Total	13.16	
			(C) Quantity of product	30.00	m3
			(D) Unit of product(A/C+B/C)	2.32	
Material					
				0.00	
			(E) Total	0.00	
Unit cost (R$)			(D)+(E)	2.32	per m3

Table16- 2 Demolition of existing medium platation (demolish curbs, move plan ,transport distance 5km, replantation)

Construction work	Demolition of existing medium platation (demolish curbs, move plan ,transport distance 5km, replantation)				
Unit of work	1.00 m3				
Work item	Quantity of work	Unit	Uunit-price (R$)	Sub.total (R$)	Remarks
Equipment					
DumpTruck	1.00	hr.	56.44	56.44	
Backhoe	1.00	hr.	45.42	45.42	
Truck with crane	1.00	hr.	39.67	39.67	
Mobil Crane	0.80	hr.	255.00	204.00	
			(A) Total	345.53	
Labor					
Foreman	0.50	hr.	5.22	2.61	
Operator	1.80	hr.	4.81	8.65	
Driver	2.00	hr.	4.29	8.58	
Skilled Worker	1.50	hr.	3.92	5.88	
Worker	2.00	hr.	2.31	4.62	
			(B) Ttotal	30.34	
			(C) Quantity of product	10.00	m3
			(D) Unit of product(A/C+B/C)	37.59	
Material					
				0.00	
			(E) Total	0.00	
Unit cost (R$)			(D)+(E)	37.59	per m3

Table16-3 Demolition of existing medium bikeway (demolish bikeway, move plan ,transport distance 5km, replantation)

Construction work	Demolition of existing medium bikeway (demolish bikeway, move plan ,transport distance 5km, replantation)				
Unit of work	1.00 m3				
Work item	Quantity of work	Unit	Uunit-price (R$)	Sub.total (R$)	Remarks
Equipment					
DumpTruck	1.00	hr.	56.44	56.44	
Bulltozer	2.00	hr.	106.20	212.40	
Backhoe	1.50	hr.	74.45	111.67	
Truck with crane	1.00	hr.	39.67	39.67	
Mobil Crane	1.00	hr.	255.00	255.00	
			(A) Total	675.18	
Labor					
Foreman	0.50	hr.	5.22	2.61	
Operator	4.50	hr.	4.81	21.64	
Driver	2.00	hr.	4.29	8.58	
Worker	4.00	hr.	2.31	9.24	
			(B) Ttotal	42.07	
			(C) Quantity of product	5.00	m3
			(D) Unit of product(A/C+B/C)	143.45	
Material					
				0.00	
			(E) Total	0.00	
Unit cost (R$)			(D)+(E)	143.45	per m3

Table16- 4 Demolition of existing light and electric pole

Construction work	Demolition of existing light and electric pole				
Unit of work	1.00 vol				
Work item	Quantity of work	Unit	Uunit-price (R$)	Sub.total (R$)	Remarks
Equipment					
DumpTruck	0.50	hr.	56.44	28.22	
Backhoe	0.50	hr.	45.42	22.71	
Truck with crane	0.40	hr.	39.67	15.86	
			(A) Total	66.79	
Labor					
Foreman	1.00	hr.	5.22	5.22	
Operator	0.50	hr.	4.81	2.40	
Driver	0.90	hr.	4.29	3.86	
Technician(electrician)	3.00	hr.	3.92	11.76	
Worker	6.00	hr.	2.31	13.86	
			(B) Ttotal	37.10	
			(C) Quantity of product	1.00	vol
			(D) Unit of product(A/C+B/C)	103.89	
Material					
				0.00	
			(E) Total	0.00	
Unit cost (R$)			(D)+(E)	103.89	per vol

Table16- 5 Excavation - commom soil (excavate, load , transport distance 5km, unload)

Construction work	Excavation - commom soil (excavate, load , transport distance 5km, unload)				
Unit of work	1.00 m3				
Work item	Quantity of work	Unit	Uunit-price (R$)	Sub.total (R$)	Remarks
Equipment					
DumpTruck	1.50	hr.	56.44	84.66	
Backhoe	2.00	hr.	45.42	90.84	95hp
			(A) Total	175.50	
Labor					
Foreman	0.50	hr.	5.22	2.61	
Operator	2.00	hr.	4.81	9.62	
Driver	1.50	hr.	4.29	6.43	
Worker	4.00	hr.	2.31	9.24	
			(B) Ttotal	27.90	
			(C) Quantity of product	50.00	m3
			(D) Unit of product(A/C+B/C)	4.07	
Material					
				0.00	
			(E) Total	0.00	
Unit cost (R$)			(D)+(E)	4.07	per m3

Table16- 6 Excavation - existing asphalt include base and sub-base (excavate, load , transport distance 5km, unload)

Construction work	Excavation - existing asphalt include base and sub-base (excavate, load , transport				
Unit of work	1.00 m3				
Work item	Quantity of work	Unit	Uunit-price (R$)	Sub.total (R$)	Remarks
Equipment					
DumpTruck	2.00	hr.	56.44	112.88	
Motor Grader	2.00	hr.	94.03	188.06	
Backhoe	3.00	hr.	45.42	136.26	95hp
			(A) Total	437.20	
Labor					
Foreman	1.00	hr.	5.22	5.22	
Operator	5.00	hr.	4.81	24.05	
Driver	2.00	hr.	4.29	8.58	
Worker	7.00	hr.	2.31	16.17	
			(B) Ttotal	54.02	
			(C) Quantity of product	5.00	m3
			(D) Unit of product(A/C+B/C)	98.24	
Material					
				0.00	
			(E) Total	0.00	
Unit cost (R$)			(D)+(E)	98.24	per m3

Table16- 7 Backfill (fill soil, compaction)

Construction work	Backfill (fill soil, compaction)				
Unit of work	1.00 m3				
Work item	Quantity of work	Unit	Uunit-price (R$)	Sub.total (R$)	Remarks
Equipment					
Road Roller	0.15	hr.	61.52	9.22	
			(A) Total	9.22	
Labor					
Foreman	0.10	hr.	5.22	0.52	
Operator	0.15	hr.	4.81	0.72	
Worker	1.00	hr.	2.31	2.31	
			(B) Total	3.55	
			(C) Quantity of product	5.00	m3
			(D) Unit of product(A/C+B/C)	2.55	
Material					
Borrowed Soil	1.00	m3	9.00	9.00	
			(E) Total	9.00	
Unit cost (R$)			(D)+(E)	11.55	per m3

Table16-8 Subbase course for Carriageway t=40cm

Construction work	Subbase course for Carriageway t=40cm				
Unit of work	1.00 m2				
Work item	Quantity of work	Unit	Uunit-price (R$)	Sub.total (R$)	Remarks
Equipment					
Motor Grader	0.10	hr.	94.03	9.40	
Road Roller	0.10	hr.	61.52	6.15	
Tire Roller	0.10	hr.	62.02	6.20	
			(A) Total	21.75	
Labor					
Foreman	0.10	hr.	5.22	0.52	
Operator	0.30	hr.	4.81	1.44	
Worker	0.40	hr.	2.31	0.92	
			(B) Total	2.88	
			(C) Quantity of product	2.00	m2
			(D) Unit of product(A/C+B/C)	12.32	
Material					
Fine Aggregate	1.00	m3	12.00	12.00	
			(E) Total	12.00	
Unit cost (R$)			(D)+(E)	24.32	per m2

Table16-9 Base course for Carriageway t=20cm

Construction work	Base course for Carriageway t=20cm				
Unit of work	1.00 m2				
Work item	Quantity of work	Unit	Uunit-price (R$)	Sub.total (R$)	Remarks
Equipment					
Motor Grader	0.10	hr.	94.03	9.40	
Tire Roller	0.10	hr.	62.02	6.20	
Road Roller	0.10	hr.	61.52	6.15	
			(A) Total	21.75	
Labor					
Foreman	0.10	hr.	5.22	0.52	
Operator	0.30	hr.	4.81	1.44	
Worker	0.50	hr.	2.31	1.15	
			(B) Total	3.11	
			(C) Quantity of product	2.00	m2
			(D) Unit of product(A/C+B/C)	12.43	
Material					
Crush Stone	0.20	m3	35.00	7.00	
Fine Aggregate	0.80	m3	12.00	9.60	
			(E) Total	16.60	
Unit cost (R$)			(D)+(E)	29.03	per m2

Table16-10 Asphalt Pavement for Carriageway t=7.5cm

Construction work	Asphalt Pavement for Carriageway t=7.5cm				
Unit of work	1.00 m2				
Work item	Quantity of work	Unit	Uunit-price (R$)	Sub.total (R$)	Remarks
Equipment					
Asphalt Distributer	0.10	hr.	68.00	6.80	
Tire Roller	0.10	hr.	62.02	6.20	
Vibratory Roller	0.10	hr.	67.30	6.73	
Road Roller	0.10	hr.	61.52	6.15	
			(A) Total	25.88	
Labor					
Foreman	0.20	hr.	5.22	1.04	
Operator	0.40	hr.	4.81	1.92	
Skilled Worker	0.50	hr.	3.92	1.96	
Worker	1.00	hr.	2.31	2.31	
			(B) Total	7.23	
			(C) Quantity of product	1.00	m2
			(D) Unit of product(A/C+B/C)	33.11	
Material					
Asphalt	0.40	t	85.21	34.08	from producing asphalt
Emulsion	0.025	t	743.50	18.58	
			(E) Total	52.66	
Unit cost (R$)			(D)+(E)	85.77	per m2

Table16-11 Concrete 45-40 Mpa (mixing,transporting,placing,curing)

Construction work	Concrete 45-40 Mpa (mixing,transporting,placing,curing)				
Unit of work	1.00 m3				
Work item	Quantity of work	Unit	Uunit-price (R$)	Sub.total (R$)	Remarks
Equipment					
Concrete Mixing Plant	1.50	hr.	154.24	231.35	
Concrete Transit Mixer	1.00	hr.	35.58	35.58	
			(A) Total	266.93	
Labor					
Foreman	4.00	hr.	5.22	20.88	
Driver	1.00	hr.	4.29	4.29	
Technician	8.00	hr.	3.92	31.36	
Worker	12.00	hr.	2.31	27.72	
			(B) Total	84.25	
			(C) Quantity of product	2.00	m3
			(D) Unit of product(A/C+B/C)	175.59	
Material					
Fine Aggregate	0.25	m3	12.00	3.00	
Coarse Aggregate	0.75	m3	35.00	26.25	
Ordinary Portland Cement	9.00	SC(50kg	15.00	135.00	
			(E) Total	164.25	
Unit cost (R$)			(D)+(E)	339.84	per m3

Table16-12 Concrete 25-30 Mpa (mixing,transporting,placing,curing)

Construction work	Concrete 25-30 Mpa (mixing,transporting,placing,curing)				
Unit of work	1.00 m3				
Work item	Quantity of work	Unit	Uunit-price (R$)	Sub.total (R$)	Remarks
Equipment					
Concrete Mixing Plant	1.30	hr.	154.24	200.50	
Concrete Transit Mixer	1.00	hr.	35.58	35.58	
			(A) Total	236.08	
Labor					
Foreman	4.00	hr.	5.22	20.88	
Driver	1.00	hr.	4.29	4.29	
Technician	8.00	hr.	3.92	31.36	
Worker	12.00	hr.	2.31	27.72	
			(B) Total	84.25	
			(C) Quantity of product	2.00	m3
			(D) Unit of product(A/C+B/C)	160.17	
Material					
Fine Aggregate	0.30	m3	12.00	3.60	
Coarse Aggregate	0.70	m3	35.00	24.50	
Ordinary Portland Cement	6.00	SC(50kg	15.00	90.00	
			(E) Total	118.10	
Unit cost (R$)			(D)+(E)	278.27	per m3

Table16-13 Concrete Pavement for Carriageway t=22cm

Construction work	Concrete Pavement for Carriageway t=22cm				
Unit of work	1.00 m2				
Work item	Quantity of work	Unit	Uunit-price (R$)	Sub.total (R$)	Remarks
Equipment					
				0.00	
			(A) Total	0.00	
Labor					
Foreman	1.00	hr.	5.22	5.22	
Technician	4.00	hr.	3.92	15.68	
Worker	8.00	hr.	2.31	18.48	placimg curing
			(B) Total	39.38	
			(C) Quantity of product	2.00	m3
			(D) Unit of product(A/C+B/C)	19.69	
Material					
Wire net	3.00	kg	2.20	6.60	
Concrete 40Mpa	0.30	m3	339.84	101.95	transfer from plant
Incidental Expence		LS	10%	10.86	form, joint seal etc
			(E) Total	119.41	
Unit cost (R$)			(D)+(E)	139.10	per m3

Table16-14 Base course for Sidewalk/Bikeway t=20cm

Construction work	Base course for Sidewalk/Bikeway t=20cm				
Unit of work	1.00 m2				
Work item	Quantity of work	Unit	Uunit-price (R$)	Sub.total (R$)	Remarks
Equipment					
Motor Grader	0.10	hr.	94.03	9.40	
Tire Roller	0.10	hr.	62.02	6.20	
Road Roller	0.10	hr.	61.52	6.15	
			(A) Total	21.75	
Labor					
Foreman	0.10	hr.	5.22	0.52	
Operator	0.30	hr.	4.81	1.44	
Worker	1.00	hr.	2.31	2.31	
			(B) Total	4.27	
			(C) Quantity of product	6.00	m2
			(D) Unit of product(A/C+B/C)	4.34	
Material					
Coarse Aggregate	0.20	m3	35.00	7.00	
Fine Aggregate	0.80	m3	12.00	9.60	
			(E) Total	16.60	
Unit cost (R$)			(D)+(E)	20.94	per m2

Table16-15 Asphalt Pavement for Sidewalk/Bikeway t=3cm

Construction work	Asphalt Pavement for Sidewalk/Bikeway t=3cm				
Unit of work	1.00 m2				
Work item	Quantity of work	Unit	Uunit-price (R$)	Sub.total (R$)	Remarks
Equipment					
Asphalt Distributer	0.10	hr.	68.00	6.80	
Tire Roller	0.10	hr.	62.02	6.20	
Vibratory Roller	0.10	hr.	67.30	6.73	
Road Roller	0.10	hr.	61.52	6.15	
			(A) Total	25.88	
Labor					
Foreman	0.10	hr.	5.22	0.52	
Operator	0.40	hr.	4.81	1.92	
Skilled Worker	0.40	hr.	3.92	1.56	
Worker	1.00	hr.	2.31	2.31	
			(B) Total	6.31	
			(C) Quantity of product	2.00	m2
			(D) Unit of product(A/C+B/C)	16.10	
Material					
Asphalt	0.25	t	85.21	21.30	from producing asphalt
Emulsion	0.01	t	743.50	7.43	
			(E) Total	28.73	
Unit cost (R$)			(D)+(E)	44.83	per m2

Table16-16 Asphalt Pavement for Overlay t=5cm

Construction work	Asphalt Pavement for Overlay t=5cm				
Unit of work	1.00 m2				
Work item	Quantity of work	Unit	Uunit-price (R$)	Sub.total (R$)	Remarks
Equipment					
Backhoe	0.10	hr.	45.42	4.54	
Asphalt Distributer	0.10	hr.	68.00	6.80	
Tire Roller	0.10	hr.	62.02	6.20	
Vibratory Roller	0.10	hr.	67.30	6.73	
Road Roller	0.10	hr.	61.52	6.15	
			(A) Total	30.42	
Labor					
Foreman	0.40	hr.	5.22	2.08	
Operator	0.50	hr.	4.81	2.40	
Skilled Worker	1.00	hr.	3.92	3.92	
Worker	1.00	hr.	2.31	2.31	
			(B) Total	10.71	
			(C) Quantity of product	2.00	m2
			(D) Unit of product(A/C+B/C)	20.57	
Material					
Asphalt	0.25	t	85.21	21.30	from producing asphalt
Emulsion	0.03	t	743.50	22.30	
			(E) Total	43.60	
Unit cost (R$)			(D)+(E)	64.17	per m2

Table16-17 Color Asphalt Pavement t=5.0cm

Construction work	Color Asphalt Pavement t=5.0cm				
Unit of work	1.00 m2				
Work item	Quantity of work	Unit	Uunit-price (R$)	Sub.total (R$)	Remarks
Equipment					
Asphalt Distributer	0.10	hr.	257.06	25.70	
Tire Roller	0.10	hr.	62.02	6.20	
Vibratory Roller	0.10	hr.	67.30	6.73	
Road Roller	0.10	hr.	61.52	6.15	
			(A) Total	44.78	
Labor					
Foreman	0.20	hr.	5.22	1.04	
Operator	0.40	hr.	4.81	1.92	
Skilled Worker	1.00	hr.	3.92	3.92	
Worker	1.00	hr.	2.31	2.31	
			(B) Total	9.19	
			(C) Quantity of product	2.00	m2
			(D) Unit of product(A/C+B/C)	26.99	
Material					
Asphalt	0.30	t	64.17	19.24	from producing asphalt
Emulsion	0.03	t	743.50	22.30	
Incidental Expence		LS	30%	12.46	Color paint
			(E) Total	54.00	
Unit cost (R$)			(D)+(E)	80.99	per m2

Table16-18 Reinforcement (cutting, bending ,assembling)

Construction work	Reinforcement (cutting, bending ,assembling)				
Unit of work	1.00 kg				
Work item	Quantity of work	Unit	Uunit-price (R$)	Sub.total (R$)	Remarks
Equipment					
				0.00	
				0.00	
			(A) Total	0.00	
Labor					
Foreman	0.50	hr.	5.22	2.61	
Carpentor	1.00	hr.	3.92	3.92	
Worker	1.00	hr.	2.31	2.31	
			(B) Total	8.84	
			(C) Quantity of product	10.00	t
			(D) Unit of product(A/C+B/C)	0.88	
Material				0.00	
Reinforcing Bar	1.00	kg	1.85	1.85	
Wire	0.03	kg	2.20	0.06	
			(E) Total	1.91	
Unit cost (R$)			(D)+(E)	2.79	per kg

Table16-19 Pipe culvert(φ1.0,1.5m)

Construction work	Pipe culvert(φ1.0,1.5m)				
Unit of work	1.00 m				
Work item	Quantity of work	Unit	Uunit-price (R$)	Sub.total (R$)	Remarks
Equipment					
Truck with crane	0.20	hr.	39.67	7.93	
Tamper/Rummer	0.20	hr.	12.51	2.50	
				0.00	
			(A) Total	10.43	
Labor					
Foreman	0.20	hr.	5.22	1.04	
Skilled worker	2.00	hr.	3.92	7.84	
Worker	5.00	hr.	2.31	11.55	
			(B) Total	20.43	
			(C) Quantity of product	1.00	m
			(D) Unit of product(A/C+B/C)	30.86	
Material				0.00	
Concrete Pipe(φ1.0m)	1.00	m	68.60	68.60	
Concrete Pipe(φ1.5m)	1.00	m	102.90	102.90	
			0.00	0.00	
			(E) Total	68.60	Concrete Pipe(φ1.0m)
			(E) Total	102.90	Concrete Pipe(φ1.5m)
Unit cost (R$)			(D)+(E)	99.46	per m Concrete Pipe(φ1.0m)
Unit cost (R$)			(D)+(E)	133.76	per m Concrete Pipe(φ1.5m)

Table16-20 Medium plantation W=2.5m (plantation , curb)

Construction work	Medium plantation W=2.5m (plantation , curb)				
Unit of work	1.00 m				
Work item	Quantity of work	Unit	Uunit-price (R$)	Sub.total (R$)	Remarks
Equipment					
				0.00	
			(A) Total	0.00	
Labor					
Foreman	0.10	hr.	5.22	0.52	
Skilled worker	1.00	hr.	3.92	3.92	
Worker	4.00	hr.	2.31	9.24	
			(B) Total	13.68	
			(C) Quantity of product	1.00	m
			(D) Unit of product(A/C+B/C)	13.68	
Material					
Grass	2.50	m2	4.62	11.55	
Curb(concrete Brick)	1.50	m2	16.00	24.00	
Soil	1.00	m3	9.00	9.00	
			(E) Total	44.55	
Unit cost (R$)			(D)+(E)	58.23	per m

Table16-21 U Shaped concrete drainage0.3*0.5m

Construction work	U Shaped concrete dranage0.3*0.5m				
Unit of work	1.00 m				
Work item	Quantity of work	Unit	Uunit-price (R$)	Sub.total (R$)	Remarks
Equipment					
Tamper/Rummer	0.20	hr.	12.51	2.50	
				0.00	
			(A) Total	2.50	
Labor					
Foreman	0.10	hr.	5.22	0.52	
Skilled worker	0.50	hr.	3.92	1.96	
Worker	2.00	hr.	2.31	4.62	
			(B) Total	7.10	
			(C) Quantity of product	1.00	m
			(D) Unit of product(A/C+B/C)	9.60	
Material					
U Concrete	1.00	m	13.72	13.72	
		m	0.00	0.00	
			45.00	0.00	
			(E) Total	13.72	
Unit cost (R$)			(D)+(E)	23.32	per m

Table16-22 Lane marking for pavement

Construction work	Lane marking for pavement				
Unit of work	1.00 m				
Work item	Quantity of work	Unit	Uunit-price (R$)	Sub.total (R$)	Remarks
Equipment					
		hr.		0.00	
		hr.		0.00	
			(A) Total	0.00	
Labor					
Foreman	0.10	hr.	5.22	0.52	
Skilled Worker	0.50	hr.	3.92	1.96	
Worker	1.50	hr.	2.31	3.46	
			(B) Total	5.94	
			(C) Quantity of product	2.00	m
			(D) Unit of product(A/C+B/C)	2.97	
Material					
Paint for pavement	1.20	kg	4.60	5.52	
Incidental Expence		LS	50%	2.76	tack coat
			(E) Total	8.28	
Unit cost (R$)			(D)+(E)	11.25	per m

Price of Paint is based on that in Japan \165*0.028= R$4.6 /kg

Table16-23 Signboard

Construction work	Signboard				
Unit of work	1.00 vol				
Work item	Quantity of work	Unit	Uunit-price (R$)	Sub.total (R$)	Remarks
Equipment					
Backhoe	0.10	hr.	45.42	4.54	
Truck with crane	0.50	hr.	39.67	19.83	
			(A) Total	24.37	
Labor					
Foreman	0.10	hr.	5.22	0.52	
Operator	0.10	hr.	4.81	0.48	
Worker	5.00	hr.	2.31	11.55	
			(B) Total	12.55	
			(C) Quantity of product	1.00	vol
			(D) Unit of product(A/C+B/C)	36.92	
Material					
Sign Board	0.20	t	1,960.00	392.00	1.5m*1.5m
Steel Column	0.20	t	2200.00	440.00	φ15cm*7m
			(E) Total	832.00	
Unit cost (R$)			(D)+(E)	868.92	per vol

Table16-24 Cat-eye

Construction work	Cat-eye				
Unit of work	1.00 vol				
Work item	Quantity of work	Unit	Uunit-price (R$)	Sub.total (R$)	Remarks
Equipment					
		hr.		0.00	
		hr.		0.00	
			(A) Total	0.00	
Labor					
Foreman	0.10	hr.	5.22	0.52	
Skilled Worker	1.00	hr.	3.92	3.92	
Worker	1.00	hr.	2.31	2.31	
			(B) Total	6.75	
			(C) Quantity of product	1.00	vol
			(D) Unit of product(A/C+B/C)	6.75	
Material					
Cat-eye	1.00	no	42.00	42.00	
			(E) Total	42.00	
Unit cost (R$)			(D)+(E)	48.75	per vol

Price of Cat-eye is based on that in Japan \1500*0.028= R$42. /kg

Table16-25 Scaffolding (steel materials)

Construction work	Scaffolding (steel materials)				
Unit of work	1.00 m2				
Work item	Quantity of work	Unit	Uunit-price (R$)	Sub.total (R$)	Remarks
Equipment					
				0.00	
				0.00	
			(A) Total	0.00	
Labor					
Foreman	0.10	hr.	5.22	0.52	
Carpentor	2.00	hr.	3.92	7.84	
Worker	2.00	hr.	2.31	4.62	
			(B) Total	12.98	
			(C) Quantity of product	1.00	m2
			(D) Unit of product(A/C+B/C)	12.98	
Material					
Section Steel(shaped)	0.06	ton	550.00	33.00	reused 4times
Incidental Expence		LS	30%	9.90	joint screw, lateral mem.etc.
			(E) Total	42.90	
Unit cost (R$)			(D)+(E)	55.88	per m2

Table16-26 Formwork

Construction work	Formwork				
Unit of work	1.00 m2				
Work item	Quantity of work	Unit	Uunit-price (R$)	Sub.total (R$)	Remarks
Equipment					
Mobile Crane	0.50	hr.	255.00	127.50	
		hr.		0.00	
				0.00	
			(A) Total	127.50	
Labor					
Foreman	1.00	hr.	5.22	5.22	
Skilled worker	2.00	hr.	3.92	7.84	
Worker	5.00	hr.	2.31	11.55	
			(B) Total	24.61	
			(C) Quantity of product	10.00	m2
			(D) Unit of product(A/C+B/C)	15.21	
Material				0.00	
Steel Form(plate)	0.07	t	490.00	34.30	reuse 4times
Incidental Expence		LS	30%	10.29	
			(E) Total	44.59	
Unit cost (R$)			(D)+(E)	59.80	per m2

Table16-27 Support example-018

Construction work	Support				
Unit of work	1.00 m3				
Work item	Quantity of work	Unit	Uunit-price (R$)	Sub.total (R$)	Remarks
Equipment					
Mobile Crane	0.50	hr.	255.00	127.50	
				0.00	
			(A) Total	127.50	
Labor					
Foreman	1.00	hr.	5.22	5.22	
Skilled worker	4.00	hr.	3.92	15.68	
Worker	5.00	hr.	2.31	11.55	
			(B) Total	32.45	
			(C) Quantity of product	15.00	m3
			(D) Unit of product(A/C+B/C)	10.66	
Material					
Pipe support (steel shape)	0.13	t	550.00	71.50	reuse 4times
Incidental Expence		LS	30%	21.45	joint screw, lateral mem.etc.
			(E) Total	92.95	
Unit cost (R$)			(D)+(E)	103.61	per m3

Table16-28 Prestress Cable (assembling,prestressing, anchoring)

Construction work	Prestress Cable (assembling,prestressing, anchoring)				
Unit of work	1.00 ton				
Work item	Quantity of work	Unit	Uunit-price (R$)	Sub.total (R$)	Remarks
Equipment					
Mobile Crane	1.00	hr.	255.00	255.00	
			(A) Total	255.00	
Labor					
Foreman	8.00	hr.	5.22	41.76	
Operator	1.00	hr.	4.81	4.81	
Skilled worker	12.00	hr.	3.92	47.04	
Worker	12.00	hr.	2.31	27.72	
			(B) Total	121.33	
			(C) Quantity of product	1.00	ton
			(D) Unit of product(A/C+B/C)	376.33	
Material					
Prestressing Cable(7nos. 1	1.00	t	3,030.00	3,030.00	
Incidental Expence		LS	50%	1,515.00	grout,anchorage,etc
				0.00	
			(E) Total	4,545.00	
Unit cost (R$)			(D)+(E)	4,921.33	per ton

Table16-29 Void Form (steel form)

Construction work	Void Form (steel form)				
Unit of work	1.00 m				
Work item	Quantity of work	Unit	Uunit-price (R$)	Sub.total (R$)	Remarks
Equipment					
Mobile Crane	0.10	hr.	255.00	25.50	
			(A) Total	25.50	
Labor					
Foreman	0.20	hr.	5.22	1.04	
Worker	3.00	hr.	2.31	6.93	
			(B) Total	7.97	
			(C) Quantity of product	2.00	m
			(D) Unit of product(A/C+B/C)	16.74	
Material					
Steel form	0.020	t	1,960.00	39.20	
Incidental Expence		LS	30%	11.76	
				0.00	
			(E) Total	50.96	
Unit cost (R$)			(D)+(E)	67.70	per m

Unit weight =20kg/m

Table16-30 Steel Pile(φ0.6m)

Construction work	Steel Pile(φ0.6m)				
Unit of work	1.00 m				
Work item	Quantity of work	Unit	Uunit-price (R$)	Sub.total (R$)	Remarks
Equipment					
Mobile Crane	0.50	hr.	443.50	221.75	
Incidental Expence		LS	50%	110.88	hammer
			(A) Total	332.63	
Labor					
Foreman	1.00	hr.	5.22	5.22	
Operator	0.30	hr.	4.81	1.44	
Skilled Worker	3.00	hr.	3.92	11.76	
Worker	6.00	hr.	2.31	13.86	
			(B) Total	32.28	
			(C) Quantity of product	3.00	m
			(D) Unit of product(A/C+B/C)	121.64	
Material					
Steel Pile	0.12	t	2,200.00	264.00	φ0.6m
Incidental Expence		LS	50%	132.00	welding,etc
			(E) Total	396.00	
Unit cost (R$)			(D)+(E)	517.64	per m

Table16-31 RC Pile(0.4*0.4m) (manufacture,driving)

Construction work	RC Pile(0.4*0.4m) (manufacture,driving)				
Unit of work	1.00 m				
Work item	Quantity of work	Unit	Uunit-price (R$)	Sub.total (R$)	Remarks
Equipment					
Mobile Crane	1.00	hr.	443.50	443.50	
Incidental Expence		LS	50%	221.75	hammer
			(A) Total	665.25	
Labor					
Foreman	1.00	hr.	5.22	5.22	
Operator	2.00	hr.	4.81	9.62	
Skilled Worker	4.00	hr.	3.92	15.68	
Worker	10.00	hr.	2.31	23.10	
			(B) Total	53.62	
			(C) Quantity of product	5.00	m
			(D) Unit of product(A/C+B/C)	143.77	
Material					
Concrete 25Mpa	0.16	m3	278.27	44.52	
Reinforcemint	50.00	kg	2.79	139.70	
Incidental Expence		LS	20%	36.84	
			(E) Total	221.06	
Unit cost (R$)			(D)+(E)	364.84	per m

Table16-32 Steel Girder(manufacturing, erection)

Construction work	Steel Girder(manufacturing, erection)				
Unit of work	1.00 ton				
Work item	Quantity of work	Unit	Uunit-price (R$)	Sub.total (R$)	Remarks
Equipment					
Mobile Crane	1.75	hr.	443.50	776.12	50t
Incidental Expence		LS	50%	388.06	
			(A) Total	1,164.18	
Labor					
Foreman	5.00	hr.	5.22	26.10	
Operator	2.00	hr.	4.81	9.62	
Driver	2.00	hr.	4.29	8.58	
Skilled Worker	10.00	hr.	3.92	39.20	
Worker	10.00	hr.	2.31	23.10	
			(B) Total	83.50	
			(C) Quantity of product	1.00	ton
			(D) Unit of product(A/C+B/C)	1,247.68	
Material					
Steel Girder	1.00	t	2,200.00	2,200.00	
Incidental Expence		LS	50%	1,100.00	welding,bolt,etc
			(E) Total	3,300.00	
Unit cost (R$)			(D)+(E)	4,547.68	per ton

Table16-33 Geotextil

Construction work	Geotextil				
Unit of work	1.00 m2				
Work item	Quantity of work	Unit	Uunit-price (R$)	Sub.total (R$)	Remarks
Equipment					
				0.00	
				0.00	
			(A) Total	0.00	
Labor					
Foreman	1.00	hr.	5.22	5.22	
Skilled Worker	2.00	hr.	3.92	7.84	
Worker	3.00	hr.	2.31	6.93	
				0.00	
			(B) Total	19.99	
			(C) Quantity of product	1.00	m2
			(D) Unit of product(A/C+B/C)	19.99	
Material					
Geosheet	1.00	m2	23.80	23.80	
Incidental Expence		LS	30%	7.14	
				0.00	
			(E) Total	30.94	
Unit cost (R$)			(D)+(E)	50.93	per m2

Price of Geosheat is based on that in Japan \800*0.028=23.8

Appendix-D
D.17 Environmental Impact Assessment

D.17 ENVIRONMENTAL IMPACT ASSESSMENT

(1) Case Study of Expropriation and Resettlement caused by Public Works in Belem

Four (4) projects as case studies of expropriation and resettlement caused by the public work done in the Belem Metropolitan Area were studied. (Refer to Figure D-1.)

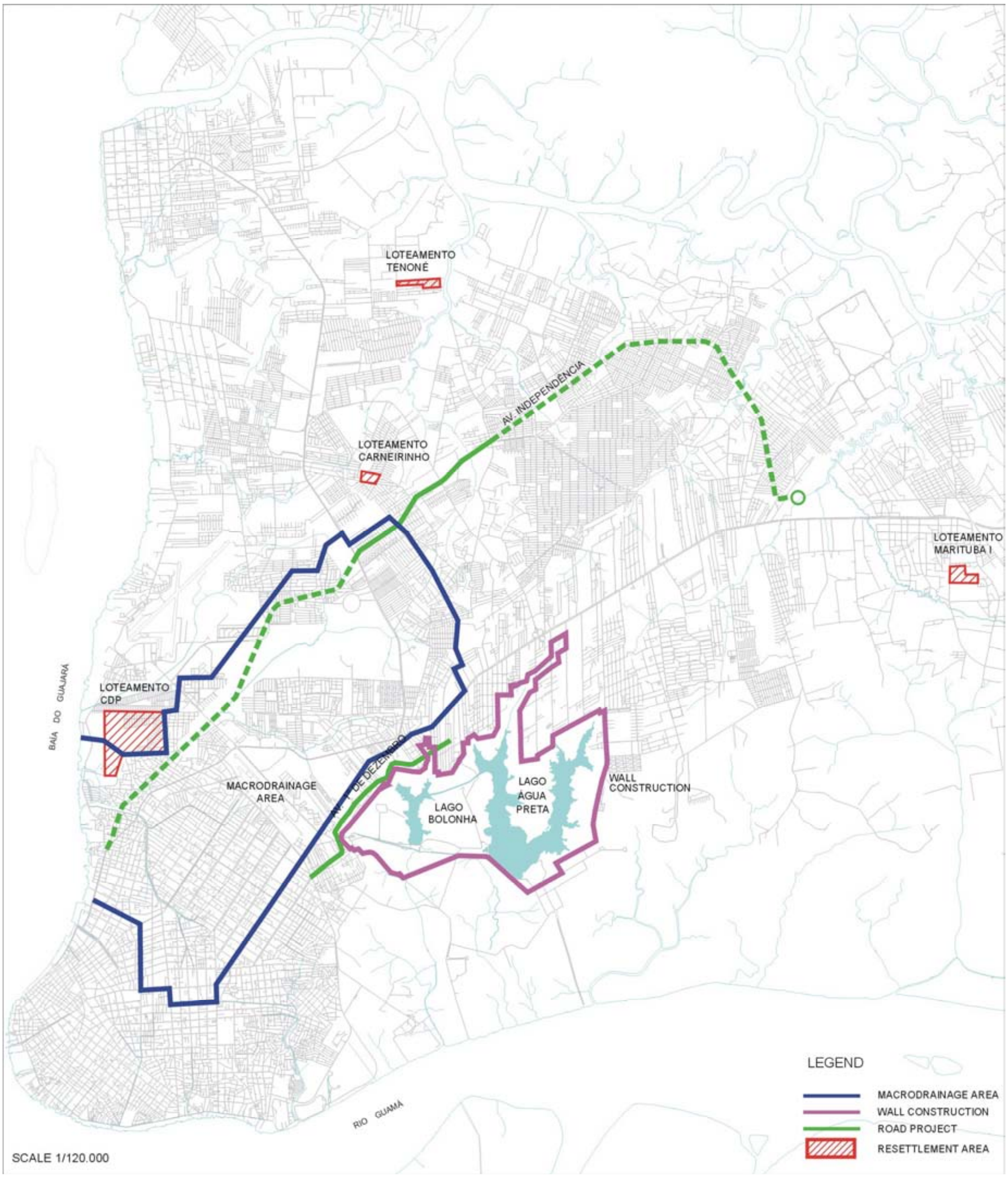


Figure D-1 Location of Case Study Projects and Resettlement Areas

(2) Wall Construction Project for protection of water resource - COHAB

Objective of the Project:

To protect the quality of the source of water supplying Belem Municipality

Project Area: Surrounding area of Lake Agua Preta and Lake Bolonha

Implementation Body: Government of the State of Para

Beginning of the Project: Year 1999

Project Components:

The main components of this project are to move out families illegally occupying land within a protection area for the source of drinking water. To achieve this, construction of a wall (total 18km, (2km has already been constructed), refer to) surrounding the area of Lake Agua Preta and Lake Bolonha had been planned.

Project Cost:

Construction of Wall – R$1.6 million

Beginning of Negotiation for Expropriation: March 2001

Total Number of Families Affected by the Project: 1,215 families

Total Compensation Cost for the Project:

Total compensation cost for the project is about R$14.0 million

Process of Expropriation and Resettlement:

Expropriation and resettlement was conducted as follows:

1) Identification and demarcation of necessary protection area
2) Identification of families to be removed (1,215 families)
3) Meetings and discussions with community leaders and families
4) Implementation of physical and socio-economic survey
5) Evaluation of properties
6) Provision of alternative of compensation for each family
   - Compensation in cash
   - New plot and house provided by COHAB (COHAB developed three new residential areas with infrastructure and a total of 791 plots, and is preparing houses for families moving in.)
7) Meetings and discussions with community leaders and families

Present Situation of Expropriation and Resettlement:

- Thirty-two percent of families agreed to move to plots and houses provided by COHAB. The size of each plot and house they moved in was 160m2 and 25m2 respectively with a bedroom, a kitchen and a bathroom. In case the property evaluation was over R$7,500, the family could have a 29.64m2 house with two bedrooms, a kitchen and a bathroom. The average cost paid for a plot and a house was approximately R$7,550 (R$3,000 for land and R$4,550 for the house).

- Thirty percent of families agreed to receive compensation in cash for resettlement to a place they found themselves. Average money received was R$6,150 per house.
- However, the remaining 38% of families are still negotiating with COHAB.
- All families having land legally (10% of total families removed) are still negotiating with COHAB on expropriation.
- Compensation in cash proposed for a summer house and a vacant lot are R$8,000 ~ R$12,000 respectively.

Photo D-1 Wall Constructed Near Lake Agua Preta and Lake Bolonha

(3) PROJETO UNA (Macro Drainage) - COSANPA

Objective of the Project:

To improve the urban environment and inhabitants' living conditions by developing canals, a rainwater drainage system (road surface), sewage system, and drinking water supply system

Project Area: Una Basin, which is one of eight basins in Belem Municipality with 3.644,1 ha.

Implementation Body: Para State

Beginning of Project: Year 1984

Project Components and Scale:

Main components and scales of the project are as follow.

Table D-1 Main components

Project Component	Unit	Amount
Canals/Gallery Development (Refer to Photo 7.5-2.)	km	24.2
Development of Bridges/Overpasses	unit	79
Road Development	km	157.2
Rainwater Drainage System Development	km	16.3
Sewage System/Connection System Development	km	283.9
Installation of Cesspits	unit	26,656
Drinking Water Supply System Development	km	148.3

Photo D-2 Improved Canal

Project Cost and Resource:

Project cost by resource was as follows.

(Million US$)

State Government	IDB	Total
126.0	145.0	271.0

Beginning of Negotiation for Expropriation: Year 1993

Total Number of Families Affected by the Project:

The total number of houses affected by the project was about 4,310.

Of these, residents of 2,300 houses were resettled. For residents of 2,010 houses that were affected, part of their land and/or house could remain at its original place to be repaired partially.

Total Compensation Cost for the Project:

Total compensation cost for the project was R$20,588,250.59.

Process of Expropriation and Resettlement:

The expropriation and resettlement process done in this project was as follows:

1) Declaration of public utility the project of a road or canal construction

2) Decree of expropriation by the governor or mayor

3) Plotting the properties to be expropriated

4) Topographic survey

5) Meeting with community members

6) Field work (physical territorial survey (photos and descriptions of properties, socio-economic survey), economic and cultural situation of the families with all characteristics)

7) Start of the process (number, name and method for removal)

8) Appraisal

9) Making the appraisal reports and presenting to owners

10) Send the process for further revision by a higher level of authority

11) Summons of owners with the date and time

12) Negotiation with owners

If owners agree, then allocate lots and approve construction of houses

If they do not agree, then send to the court of law

13) Monitoring of the construction (layout, location, construction implementation)

14) Resettlement and starting of the service (water, electricity and telephone)

15) Issue owner's documentation

Present Condition of Expropriation and Resettlement:

- Total cost used as compensation for expropriation of land of 4,310 families was about R$20.6 million and average compensation money each family received was about R$4,780.

- Resettlement of residents of 2,300 houses (including houses under negotiation for resettlement) had been completed in about the average four months for each negotiation between 1994 and 2002, of which 5% are between 1994 and 1996 and 95% between 1997 and 2002.

- They moved out to a new residential place provided by COSANPA and COHAB near their original residential area.

- They received about R$8,560 per family as compensation and built their houses there.

- The new place developed as a residential area has about 2,017 lots with utilities (water supply, drainage, electricity, etc.) and community facilities such as schools, halls, parks, etc. (Refer to Photo D-3.)

Photo D-3 New Residential Area for Resettlement

(4) Extension of AVENIDA Primeiro DE DEZEMBRO - Belem Municipality

Objective of the Project:

To construct a new inter-municipal corridor and mitigate current traffic congestion on Av. Almirante Barroso.

Total planned length of this road is about 15.6km. Of this, 4.6km is now being implemented by Belem Municipality. (Photo D-4)

Photo D-4 Under Construction of AVENIDA PRIMEIRO DE DEZEMBRO

The remaining portion of this road between Al. Moça Bonita and Alça Viária is now being studied by COHAB in the state and by the study team.

Project Area:

Between Avenida Dr. Freitas and Alameda Moca Bonita (Belem Municipality area)

Implementation Body: Belem Municipality

Beginning of the Project: Year 1998

Project Component: Road construction (length: 4.6km)

Beginning of Negotiation for Resettlement: Year 2001

Total Number of Families Affected by the Project:

The total number of houses and buildings affected was 221.

Process of Expropriation and Resettlement:

Not available.

Present Condition of Expropriation and Resettlement:

- The municipality provided apartment buildings with 120 flats for families resettled.
- However, people did not like to live in apartment houses because of their custom.
- Only 76 households received compensation money and moved out to other places they found.
- Residents of the remaining 145 houses are still negotiating with the municipality.
- The municipality will complete the resettlement by the end of year 2002.

(5) AVENIDA INDEPENDENCIA Construction - Para State

Objective of the Project:

To mitigate traffic congestion of existing main road and to implant an alternative corridor to Rodovia BR-316 and Avenida Almirante Barroso, linking the areas of Cidade Nova set to Belem Centro and reducing the existing problems of traffic saturation verified in these corridors.

Project Area:

Area along Sao Joaquim Canal (a part of the Macro Drainage Project) and below the transmission line from Av. Julio Cesar to Rod BR-316

Implementation Body: Government of the State of Para

Beginning of the Project:

Phase I – after completion of the macro drainage project (not decided yet)

Phase II – Section I: already started in 1992 (Refer to Photo D-5.)

Section II and III: not decided yet

Photo D-5 AVENIDA INDEPENDENCIA Under Construction (Phase II-Section I)

Project Component:

Road construction – 20.8km (Phase I – 8.2km, Phase II – 12.6km)

Beginning of Negotiation for Resettlement: Phase II - 2001

Total Number of Families Affected by the Project:

The total number of houses affected in Phase II is 982.

Phase II is divided into three small sections. Section I, II, and III have 404, 478 and about 100 houses affected by Phase II construction work respectively.

Total Compensation Cost for the Project:

Total compensation cost for Section I in Phase II is as follows:

Description	No. of families	Cost (R$)	Remarks
Already Paid	353	2,204,252.40	
To be Paid	51	620,548.80	
Total	404	2,824,801.20	Average R$6,990

Process of Expropriation and Resettlement:

1st Phase

1) Survey the registers of the properties
2) Prepare socio-economic reference file of the families
3) Make the appraisal reports
4) Organize the processes (socio-economic study, photos, sketches, appraisal reports, additional technical information files, file on the evaluation of the cases, declarations

and documentation of owners)

2nd Phase

1) Summon the property owners
2) Negotiations
3) Send the processes
    a) Payment (COHAB/SECTRAN)
    b) Legal counsels: Payment (if no changes in the appraisal report) otherwise settle in court

3rd Phase

1) Payment of expropriation
2) Check the removal from the properties

Present Condition of Expropriation and Resettlement:

- Section I of Phase II has already begun construction of the road.
- Total cost for compensation provided for 404 families removed is R$2,824,801.
- In Section I, 351 of 404 families had already agreed on resettlement with the state.
- Of these, 100 families received money (average R$16,330) from COHAB and 196 families got compensation in cash (average R$2,130) from SETRAN. They moved out to other places they found.
- Twenty-seven families received money (average R$4,520) and moved in to the new residential area provided by the state.
- Twenty-eight properties are not within the project area, however, they may be expropriated if necessary. They agreed to be expropriated and will receive a certain amount of money.
- It took only about four months to finish procedures for expropriation and resettlement of 353 families, which is over 85% of the total.
- 51 of 404 families are now negotiating or in the court for arbitration.
- Of these, 22 families did not agree to the state's offer (average R$9,770), and now the court is mediating on the price between the two parties. Twenty-five families are negotiating on compensation (average R$16,230) offered by the state.

(6) Result of Case Study

In all four (4) cases, the procedure of expropriation and compensation for resettlement has been implemented obeying the law. They never expropriated properties nor resettled people compulsorily.

Table D-2 shows characteristics and situation of expropriation by case study project.

Table D-2 Characteristics and Situation of Expropriation by Case Study Project

Project Name	Wall Construction	Primeiro de Dezembro	Macro Drainage	Independencia Phase II, Section I
Location of Project	Near urban area	Near urban area	Within urban area	Suburban area
Characteristics of Project	-Protection of area for water source -Secure vast area	-Road construction -Line development	-Redevelopment of urban area	-Road construction -Line development
Property/Homes Expropriated	-Total 1,215	-Total 221	-Total 4,310	-Total 404
New Residential Area provided by Project	New area, but far from the project area	Apartment-type buildings	New area near the project area	New area near the project area
Situation of Expropriation and Resettlement	About 40% are still negotiating	145 families are sti ll negotiating.	Almost completed	Almost completed

From the point of view of expropriation and compensation, there were two cases that have been implemented very smoothly and two cases that have not.

1) Successful Cases

In the cases of Macro-Drainage and Av. Independencia, it took only about the average four (4) months per family to complete the procedure from beginning of expropriation and end of resettlement. The main reason that they were implemented smoothly is that both projects provided new residential areas for inhabitants resettled by public projects at places near where the inhabitants lived before. Therefore, they could continue their work and/or businesses at the same place, and they did not oppose resettlement so strongly.

Furthermore, they lived under bad environmental conditions before. Infrastructure such as roads, water supply, drainage and sewage were not developed well at previous residential areas where they lived. However, the new residential area provided not only well-developed infrastructure but also community halls, schools, parks and clinics that are indispensable to form a community. They can live in a good living environment.

2) Difficult Cases

Procedures of expropriation and resettlement for the Wall Construction Project and Extension of Avenida Primeiro de Dezembro took a long time and have not been finished yet.

Two projects are being implemented at places very near to an urban area and to a main road. Therefore, people living in these areas can go their work places and/or get jobs easily. They also are getting services of water supply, electricity. It is a very convenient place for them to live.

These two projects also provided new places or housing for resettlement. However, the provided new places were far from the original places that people were living. Furthermore, the provided housing was apartment buildings, which people did not have a custom of living in and they did not want to live together in separated spaces within a building.

In this study, the study team proposes two new projects for improvement of the transport system in the metropolitan area of Belem. Expropriation of property and resettlement of inhabitants will be a big obstacle when new projects will be implemented.

To avoid this and to carry out projects smoothly, it is very important to provide new resettlement land at places near where inhabitants to be moved by new projects live at present. Provision of enough budget for expropriation and resettlement is also important.

(7) Compensation for Expropriation and Resettlement

Table D-3 shows characteristics of projects, average compensation cost of projects and average compensation cost for families resettled by case study project.

Table D-3 Characteristics and Compensation Cost by Case Study Project

Project Name	Wall Construction	Primeiro De Dezembro	Macro Drainage	Independencia
Location of Project	Near urban area	Near urban area	Within urban area	Suburb area
Characteristics of Project	-Protection of area for water source -Secure vast area	-Road construction -Line development	-Drainage with Redevelopment of urban area	-Road construction -Line development
Average Compensation Cost of Project (R$/family)	11,520	No data	4,780	6,990
Average Compensation Cost of Family Moved to New Area Provided (R$/family)	7,550	No data	8,560	4,520

Compensation cost that should be provided is largely affected by characteristics of a project and property expropriated by a project implemented.

Projects proposed in this study are improvement and/or construction of roads and introduction of the trunk bus system. Roads that will be improved and/or constructed are or will be all located near urban or suburban areas of Belem Municipality.

Considering that projects are improvement and/or construction of roads and that locations of roads are near urban or suburban areas, average compensation cost per family for land expropriated by "the Independencia Road Construction Project" will be a good guide for the proposed road projects. Therefore, to estimate the compensation cost for the road projects US$2,500 (x R$2.8/US$ = R$7,000) as a unit cost per family will be employed. However, this figure should be reconsidered when route and width of the roads proposed are decided and more detailed characteristics of properties to be expropriated are investigated.

Appendix-E

E.20 Economic And Financial Evaluation

E.20 ECONOMIC AND FINANCIAL EVALUATION

Table E-1 Investment Schedule in Financial and Economic Cost

Table E-1 (1) Av. Almirante Barroso (R$,unit1000)

Year	Financial Cost								Economic Cost							
	Direct Cost	Indirect Cost	Construc-tion Cost	Engineer-ing Service	Contin-gency	Compen-sation	Administ-ration	Total Project Cost	Direct Cost	Indirect Cost	Construc-tion Cost	Engineer-ing Service	Contin-gency	Compen-sation	Administ-ration	Total Project Cost
2004	1,764	1,852	3,615	1,146	946	0	287	5,994	1,277	1,574	2,723	951	813	0	287	4,774
2005	1,764	1,852	3,615	1,146	946	0	287	5,994	1,277	1,574	2,723	951	813	0	287	4,774
2006	14,109	1,587	15,696	0	1,891	0	573	18,160	10,215	1,349	11,820	0	1,627	0	573	14,020
2007	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2008	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2009	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2010	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	17,636	5,291	22,927	2,293	3,783	0	1,146	30,148	12,768	4,497	17,266	1,903	3,253	0	1,146	23,568

Table E-1 (2) Extra Work to Av. Almirante Barroso (R$,unit1001)

Year	Financial Cost								Economic Cost							
	Direct Cost	Indirect Cost	Construc-tion Cost	Engineer-ing Service	Contin-gency	Compen-sation	Administ-ration	Total Project Cost	Direct Cost	Indirect Cost	Construc-tion Cost	Engineer-ing Service	Contin-gency	Compen-sation	Administ-ration	Total Project Cost
2004	1,270	1,334	2,604	826	681	0	207	4,318	920	1,134	1,961	685	586	0	207	3,439
2005	1,270	1,334	2,604	826	681	0	207	4,318	920	1,134	1,961	685	586	0	207	3,439
2006	10,164	1,143	11,307	0	1,363	0	413	13,083	7,359	972	8,515	0	1,172	0	413	10,100
2007	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2008	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2009	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2010	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	12,705	3,811	16,516	1,652	2,725	0	826	21,719	9,198	3,240	12,438	1,371	2,344	0	826	16,979

Table E-1 (3) BR316 (R$,unit1000)

Year	Financial Cost								Economic Cost							
	Direct Cost	Indirect Cost	Construc-tion Cost	Engineer-ing Service	Contin-gency	Compen-sation	Administ-ration	Total Project Cost	Direct Cost	Indirect Cost	Construc-tion Cost	Engineer-ing Service	Contin-gency	Compen-sation	Administ-ration	Total Project Cost
2004	4,194	4,403	8,597	2,726	2,249	0	681	14,253	3,036	3,743	6,474	2,262	1,934	0	681	11,352
2005	4,194	4,403	8,597	2,726	2,249	0	681	14,253	3,036	3,743	6,474	2,262	1,934	0	681	11,352
2006	33,550	3,774	37,324	0	4,498	0	1,363	43,184	24,290	3,208	28,108	0	3,868	0	1,363	33,338
2007	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2008	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2009	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2010	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	41,937	12,581	54,518	5,452	8,995	0	2,725	71,690	30,362	10,694	41,056	4,525	7,736	0	2,725	56,042

Table E-11 (4) Extra Work to BR316 (R$,unit1000)

Year	Financial Cost								Economic Cost							
	Direct Cost	Indirect Cost	Construc-tion Cost	Engineer-ing Service	Contin-gency	Compen-sation	Administ-ration	Total Project Cost	Direct Cost	Indirect Cost	Construc-tion Cost	Engineer-ing Service	Contin-gency	Compen-sation	Administ-ration	Total Project Cost
2004	1,309	1,375	2,684	851	702	0	213	4,450	948	1,168	2,021	706	604	0	213	3,544
2005	1,309	1,375	2,684	851	702	0	213	4,450	948	1,168	2,021	706	604	0	213	3,544
2006	10,474	1,178	11,652	0	1,404	0	426	13,482	7,583	1,002	8,775	0	1,208	0	426	10,409
2007	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2008	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2009	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2010	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	13,092	3,928	17,020	1,702	2,808	0	852	22,382	9,479	3,339	12,817	1,413	2,415	0	852	17,497

Table E-1 (5) Rod. Augusto Montenegro (R$,unit1000)

Year	Financial Cost								Economic Cost							
	Direct Cost	Indirect Cost	Construc－tion Cost	Engineer－ing Service	Contin－gency	Compen－sation	Administ－ration	Total Project Cost	Direct Cost	Indirect Cost	Construc－tion Cost	Engineer－ing Service	Contin－gency	Compen－sation	Administ－ration	Total Project Cost
2004	3,900	4,095	7,995	2,535	2,091	0	634	13,255	2,824	3,481	6,021	2,104	1,799	0	634	10,557
2005	3,900	4,095	7,995	2,535	2,091	0	634	13,255	2,824	3,481	6,021	2,104	1,799	0	634	10,557
2006	31,201	3,510	34,711	0	4,183	0	1,268	40,161	22,589	2,984	26,140	0	3,597	0	1,268	31,004
2007	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2008	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2009	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2010	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	39,001	11,700	50,701	5,070	8,366	0	2,535	66,672	28,236	9,945	38,182	4,208	7,194	0	2,535	52,119

Table E-1 (6) Extra Work to Rod. Augusto Montenero (R$,unit1000)

Year	Financial Cost								Economic Cost							
	Direct Cost	Indirect Cost	Construc－tion Cost	Engineer－ing Service	Contin－gency	Compen－sation	Administ－ration	Total Project Cost	Direct Cost	Indirect Cost	Construc－tion Cost	Engineer－ing Service	Contin－gency	Compen－sation	Administ－ration	Total Project Cost
2004	1,978	2,077	4,055	1,286	1,061	0	322	6,723	1,432	1,766	3,054	1,067	912	0	322	5,355
2005	1,978	2,077	4,055	1,286	1,061	0	322	6,723	1,432	1,766	3,054	1,067	912	0	322	5,355
2006	15,825	1,780	17,606	0	2,122	0	643	20,370	11,458	1,513	13,258	0	1,825	0	643	15,726
2007	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2008	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2009	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2010	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	19,782	5,935	25,716	2,572	4,243	0	1,286	33,817	14,322	5,044	19,366	2,134	3,649	0	1,286	26,436

Financial Cost (Incl. Extra Work) **Economic Cost (Excl. Extra Work)**

Table E-1 (7) Av. Independencia (R$,unit1000)

Year	Financial Cost								Economic Cost							
	Direct Cost	Indirect Cost	Construc－tion Cost	Engineer－ing Service	Contin－gency	Compen－sation	Administ－ration	Total Project Cost	Direct Cost	Indirect Cost	Construc－tion Cost	Engineer－ing Service	Contin－gency	Compen－sation	Administ－ration	Total Project Cost
2004	0	0	0	2,016	2,487	12,737	972	18,212	0	0	0	1,673	2,139	12,737	972	17,521
2005	0	0	0	2,016	2,487	12,737	972	18,212	0	0	0	1,673	2,139	12,737	972	17,521
2006	30,718	9,215	39,933	1,997	3,294	0	1,236	46,460	22,240	7,833	30,073	1,657	2,833	0	1,236	35,799
2007	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2008	9,395	3,758	13,153	733	1,679	0	708	16,274	6,802	3,194	9,905	608	1,444	0	708	12,666
2009	15,658	3,758	19,416	651	1,679	0	708	22,456	11,337	3,194	14,622	541	1,444	0	708	17,315
2010	6,263	1,879	8,142	651	1,679	0	708	11,182	4,535	1,597	6,132	541	1,444	0	708	8,825
2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	62,035	18,610	80,645	8,065	13,306	25,474	5,306	132,796	44,913	15,819	60,732	6,694	11,444	25,474	5,306	109,649

Table E-1 (8) Priority Lane (R$,unit1000)

Year	Financial Cost								Economic Cost							
	Direct Cost	Indirect Cost	Construc－tion Cost	Engineer－ing Service	Contin－gency	Compen－sation	Administ－ration	Total Project Cost	Direct Cost	Indirect Cost	Construc－tion Cost	Engineer－ing Service	Contin－gency	Compen－sation	Administ－ration	Total Project Cost
2004	0	0	0	145	240	0	73	458	0	0	0	121	206	0	73	400
2005	0	0	0	867	1,430	0	433	2,730	0	0	0	719	1,230	0	433	2,382
2006	4,475	1,343	5,818	1,012	1,670	0	506	14,824	3,240	1,141	4,381	840	1,436	0	506	11,545
2007	22,189	6,657	28,846	1,442	2,380	0	721	62,235	16,065	5,658	21,723	1,197	2,047	0	721	47,411
2008	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2009	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2010	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	26,665	7,999	34,664	3,466	5,720	0	1,733	80,247	19,305	6,799	26,105	2,877	4,919	0	1,733	61,738

Table E-1 (9)Bus Facility (R$,unit1000)

Year	Financial Cost								Economic Cost							
	Direct Cost	Indirect Cost	Construc- tion Cost	Engineer- ing Service	Contin- gency	Compen- sation	Administ- ration	Total Project Cost	Direct Cost	Indirect Cost	Construc- tion Cost	Engineer- ing Service	Contin- gency	Compen- sation	Administ- ration	Total Project Cost
2004	0	0	0	884	1,459	315	458	3,116	0	0	0	734	1,254	422	458	2,869
2005	0	0	0	884	1,459	315	458	3,116	0	0	0	734	1,254	422	458	2,869
2006	27,199	8,160	35,359	1,768	2,917	630	916	76,949	19,692	6,936	26,628	1,467	2,509	845	916	58,993
2007	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2008	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2009	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2010	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	27,199	8,160	35,359	3,536	5,834	1,260	1,832	83,181	19,692	6,936	26,628	2,935	5,017	1,690	1,832	64,731

Table E-1 (10) Independensia

7.Independensia

(R$,unit1000)

Year	Financial Cost								Economic Cost							
	Direct Cost	Indirect Cost	Construc- tion Cost	Engineer- ing Service	Contin- gency	Compen- sation	Administ- ration	Total Project Cost	Direct Cost	Indirect Cost	Construc- tion Cost	Engineer- ing Service	Contin- gency	Compen- sation	Administ- ration	Total Project Cost
2004	0	0	0	3,599	4,440	15,675	1,606	25,321	0	0	0	2,988	3,818	15,675	1,606	24,087
2005	0	0	0	3,599	4,440	15,675	1,606	25,321	0	0	0	2,988	3,818	15,675	1,606	24,087
2006	54,841	16,452	71,293	3,565	5,882	0	2,042	82,782	39,705	13,984	53,689	2,959	5,058	0	2,042	63,748
2007	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2008	16,773	6,709	23,482	1,308	2,998	0	1,170	28,959	12,144	5,703	17,684	1,086	2,578	0	1,170	22,519
2009	27,955	6,709	34,664	1,163	2,998	0	1,170	39,996	20,240	5,703	26,105	965	2,578	0	1,170	30,819
2010	11,182	3,355	14,537	1,163	2,998	0	1,170	19,868	8,096	2,851	10,947	965	2,578	0	1,170	15,661
2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	110,752	33,225	143,977	14,398	23,756	31,350	8,766	222,247	80,184	28,242	108,426	11,950	20,430	31,350	8,766	180,922

Table E-1 (11) Av.Primero de Dezwembro (R$,unit1000)

Year	Financial Cost								Economic Cost							
	Direct Cost	Indirect Cost	Construc- tion Cost	Engineer- ing Service	Contin- gency	Compen- sation	Administ- ration	Total Project Cost	Direct Cost	Indirect Cost	Construc- tion Cost	Engineer- ing Service	Contin- gency	Compen- sation	Administ- ration	Total Project Cost
2004	0	0	0	3,472	1,432	4,202	487	9,592	0	0	0	2,882	1,232	4,202	487	8,802
2005	0	0	0	3,472	1,432	4,202	487	9,592	0	0	0	2,882	1,232	4,202	487	8,802
2006	0	0	0	3,472	1,432	4,202	487	9,592	0	0	0	2,882	1,232	4,202	487	8,802
2007	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2008	24,037	16,826	40,864	0	4,297	0	1,460	46,620	17,403	14,302	30,773	0	3,695	0	1,460	35,928
2009	40,062	2,404	42,466	0	4,297	0	1,460	48,222	29,005	2,043	31,980	0	3,695	0	1,460	37,135
2010	16,025	4,807	20,832	0	4,297	0	1,460	26,589	11,602	4,086	15,688	0	3,695	0	1,460	20,843
2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	80,125	24,037	104,162	10,416	17,187	12,605	5,838	150,208	58,010	20,432	78,442	8,645	14,781	12,605	5,838	120,311

Table E-1 (12) Rua Yamada (R$,unit1000)

Year	Financial Cost								Economic Cost							
	Direct Cost	Indirect Cost	Construc- tion Cost	Engineer- ing Service	Contin- gency	Compen- sation	Administ- ration	Total Project Cost	Direct Cost	Indirect Cost	Construc- tion Cost	Engineer- ing Service	Contin- gency	Compen- sation	Administ- ration	Total Project Cost
2004	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2005	0	0	0	2,209	911	2,400	306	5,826	0	0	0	1,833	784	2,400	306	5,323
2006	0	0	0	2,209	911	2,400	306	5,826	0	0	0	1,833	784	2,400	306	5,323
2007	0	0	0	2,209	911	2,400	306	5,826	0	0	0	1,833	784	2,400	306	5,323
2008	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2009	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2010	15,292	10,704	25,996	0	2,733	0	918	29,648	11,071	9,099	19,577	0	2,351	0	918	22,846
2011	25,487	1,529	27,016	0	2,733	0	918	30,667	18,452	1,300	20,345	0	2,351	0	918	23,614
2012	10,195	3,058	13,253	0	2,733	0	918	16,905	7,381	2,600	9,981	0	2,351	0	918	13,250
Total	50,973	15,292	66,265	6,627	10,934	7,201	3,673	94,699	36,905	12,998	49,903	5,500	9,403	7,201	3,673	75,680

Table E-1 (13) Rua de Marinha (R$,unit1000)

Year	Financial Cost								Economic Cost							
	Direct Cost	Indirect Cost	Construc- tion Cost	Engineer- ing Service	Contin- gency	Compen- sation	Administ- ration	Total Project Cost	Direct Cost	Indirect Cost	Construc- tion Cost	Engineer- ing Service	Contin- gency	Compen- sation	Administ- ration	Total Project Cost
2004	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2005	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2006	0	0	0	1,446	1,193	651	394	3,683	0	0	0	1,200	1,026	651	394	3,270
2007	0	0	0	1,446	1,193	651	394	3,683	0	0	0	1,200	1,026	651	394	3,270
2008	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2009	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2010	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2012	22,238	6,672	28,910	0	2,385	1,302	788	33,385	16,101	5,671	21,771	0	2,051	1,302	788	25,912
Total	22,238	6,672	28,910	2,891	4,770	2,603	1,576	40,750	16,101	5,671	21,771	2,400	4,102	2,603	1,576	32,452

Table E-2 Vehicle Operating Cost in Belem

Vehicle Type	Size	Make	Model	Fuel	Price W/ Tax	Price W/o Tax	Compo-sition(%)	Average Price W/ Tax	Average Price W/o Tax
Car	Small	VW	Gol Special	Gasoline	15,740	11,085	73.7	15,593	10,853
		VW	Gol City	Methanol	16,630	11,711	12.6		
	Medium	VW	Kombi	Gasoline	25,990	16,554	6.9		
		VW	Kombi	Methanol	25,990	16,554	0.4		
Taxi	Small	VW	Gol City	Gasoline	16,630	11,711	93.0	16,630	11,711
		VW	Gol	Methanol	16,630	11,711	7.0		
Truck	Small	GM	Chevrolet	Gasoline	19,000	16,239	1.5	48,585	39,196
		GM	Chevrolet	Methanol	19,000	16,239	0.1		
	Medium	M. BENZ	Sprinter312D	Diesel	49,060	39,565	98.4		
Bus	Large	M. BENZ	OF1620	Diesel	129,750	115,848	100.0	129,750	115,848
	Articulated	Volvo/Marcopolo		Diesel	470,000	419,643	100.0	470,000	419,643

Table E-3 Characteristics of Representative Vehicle

	Vehicle Characteristics / Vehicle Type	Car	Taxi	Truck	Large Bus (100 pax.)	Articula-ted Bus (200pax.)
1	Price(Real) (1) Financial (2) Economic	 15,593 10,853	 16,630 11,711	 48,585 39,196	 129,750 115,848	 470,000 419,643
2	No. of Tires	4	4	6	6	10
3	Fuel Type	Gasoline Ethanol	Gasoline Ethanol	Diesel	Diesel	Diesel
4	Annual Operation (Km)	24,000	60,000	48,000	75,000	90,000
5	Average Speed (Km/Hour)	30	25	30	25	30
6	Annual using hours(Hours)	800	2,400	1,600	3,000	3,000

Table E-4 Composition of Fuel Consumption and Average Fuel Cost by Type of Vehicle

(%,R$/liter)

Fuel Type	Fuel Price (R$/liter) Financial (W/ Tax)	Fuel Price (R$/liter) Economic (W/o Tax)	Car	Taxi	Truck	Large Bus (100 pax.)	Articula-ted Bus (200pax.)
Regular Gasoline(comun)	2.10	1.56	72.0	80.0	2.0		
Premium Gasoline(aditiva	2.24	1.66	8.6	13.0			
Ethanol Fuel (Alcohol)	1.61	1.19	13.0	7.0			
Diesel	1.41	1.16	6.4		98.0	100.0	100.0
Total	-	-	100.0	100.0	100.0	100.0	100.0
Av. Financial Cost(R$/liter	-	-	2.00	2.08	1.42	1.41	1.41
Av Economic Cost(R$/liter	-	-	1.49	1.54	1.16	1.16	1.16

Table E-5 Fuel Consumption Rate and Cost by Type of Vehicle

	Operatin Speed (Km/hr)	Car	Taxi	Truck	Large Bus (100 pax.)	Articula-ted Bus (200pax.)
Fuel Consum-ption Rate (Liter/1000Km)	5	242.9	368.3	1322.0	845.0	987.0
	10	158.4	240.1	845.9	540.7	631.5
	20	114.5	173.6	611.7	390.9	456.6
	30	99.4	150.7	450.0	357.0	417.0
	40	91.6	138.9	373.5	332.3	388.1
	50	89.6	135.8	343.0	357.0	417.0
	60	92.5	140.3	330.9	409.6	478.5
	70	97.9	148.4	343.0	478.5	558.9
	80	105.9	160.6	371.4	550.3	642.8
	90	117.0	177.4	410.2	607.9	710.0
Financial Fuel Cost (R$/1000km)	5	486.8	767.4	1882.3	1191.5	1391.7
	10	317.4	500.3	1204.4	762.3	890.4
	20	229.4	361.7	870.9	551.2	643.8
	30	199.2	314.0	640.7	503.4	588.0
	40	183.6	289.5	531.9	468.5	547.2
	50	179.5	283.0	488.3	503.4	588.0
	60	185.5	292.4	471.2	577.6	674.7
	70	196.2	309.4	488.3	674.6	788.0
	80	212.3	334.6	528.7	776.0	906.4
	90	234.5	369.6	584.1	857.1	1001.1
Economic Fuel Cost (R$/1000km)	5	362.3	568.5	1538.5	976.6	1140.8
	10	236.2	370.6	984.4	624.8	729.9
	20	170.8	267.9	711.8	451.8	527.7
	30	148.3	232.6	523.7	412.6	481.9
	40	136.7	214.4	434.7	384.0	448.5
	50	133.6	209.6	399.1	412.6	481.9
	60	138.0	216.6	385.1	473.4	553.0
	70	146.1	229.1	399.1	553.0	645.9
	80	158.0	247.9	432.2	636.0	742.9
	90	174.5	273.8	477.4	702.5	820.6

Table E-6 Oil Consumption Rate and Cost by Type of Vehicle

Financial Cost4.20 R$/liter
Economic Cost 3.44 R$/liter

	Speed (Km/hr)	Car	Taxi	Truck	Large Bus (100 pax.)	Articula-ted Bus (200pax.)
Oil Consumption Rate (Litter/1001Km)	5	3.48	3.48	8.01	11.61	16.02
	10	2.24	2.24	5.14	7.45	10.28
	20	1.54	1.54	3.54	5.12	7.06
	30	1.27	1.27	2.92	4.23	5.84
	40	1.13	1.13	2.68	3.89	5.36
	50	1.10	1.10	2.58	3.74	5.16
	60	1.09	1.09	2.36	3.42	4.72
	70	1.07	1.07	2.14	3.10	4.28
	80	1.00	1.00	1.87	2.71	3.74
	90	0.90	0.90	1.68	2.44	3.36
Financial Oil Cost (US$/1000km)	5	14.6	14.6	33.6	48.8	67.3
	10	9.4	9.4	21.6	31.3	43.2
	20	6.5	6.5	14.9	21.5	29.7
	30	5.3	5.3	12.3	17.8	24.5
	40	4.7	4.7	11.3	16.3	22.5
	50	4.6	4.6	10.8	15.7	21.7
	60	4.6	4.6	9.9	14.4	19.8
	70	4.5	4.5	9.0	13.0	18.0
	80	4.2	4.2	7.9	11.4	15.7
	90	3.8	3.8	7.1	10.2	14.1
Economic Oil Cost (US$/1000km)	5	12.0	12.0	27.6	40.0	55.2
	10	7.7	7.7	17.7	25.7	35.4
	20	5.3	5.3	12.2	17.6	24.3
	30	4.4	4.4	10.1	14.6	20.1
	40	3.9	3.9	9.2	13.4	18.5
	50	3.8	3.8	8.9	12.9	17.8
	60	3.8	3.8	8.1	11.8	16.2
	70	3.7	3.7	7.4	10.7	14.7
	80	3.4	3.4	6.4	9.3	12.9
	90	3.1	3.1	5.8	8.4	11.6

Table E-7 Financial and Economic Cost by Types

Item	Unit	Car	Taxi	Truck	Large Bus (100 pax.)	Articula-ted Bus (200pax.)
No. of Tyres	No./set	4	4	6	6	10
Tipe of Tire		165-70-R13GPS	175-65-R14GPS	1100-22 G358	1000-20 G358	1100-22 G358
Financial Cost (Market Price)	R$/Set	520	560	6,810	6,324	11,350
Tax	R$/Set	199.0	214.3	2606.3	2420.3	4343.8
Economic Cost	R$/Set	321	346	4,204	3,904	7,006
Tire Life	Km	45,000	45,000	50,000	50,000	50,000
Tire Consumption Rate	% / 1000km	2.2	2.2	2.0	2.0	2.0

Table E-8 Tire Consumption Rate and Cost by Type of Vehicle

	Speed (Km / hour)	Car	Taxi	Truck	Large Bus (100 pax.)	Articula-ted Bus (200pax.)
Tire Consumption Index (56km / hr =100)	5	53	53	53	53	53
	10	56	56	56	56	56
	20	60	60	60	60	60
	30	67	67	67	67	67
	40	78	78	78	78	78
	50	92	92	92	92	92
	56	100	100	100	100	100
	60	107	107	107	107	107
	70	125	125	125	125	125
	80	151	151	151	151	151
	90	180	180	180	180	180
Financial Tire Cost (R$ / 1000 km)	5	6.1	6.6	72.2	67.0	120.3
	10	6.5	7.0	76.3	70.8	127.1
	20	6.9	7.5	81.7	75.9	136.2
	30	7.7	8.3	91.3	84.7	152.1
	40	9.0	9.7	106.2	98.7	177.1
	50	10.6	11.4	125.3	116.4	208.8
	56	11.6	12.4	136.2	126.5	227.0
	60	12.4	13.3	145.7	135.3	242.9
	70	14.4	15.6	170.3	158.1	283.8
	80	17.4	18.8	205.7	191.0	342.8
	90	20.8	22.4	245.2	227.7	408.6
Economic Tire Cost (R$ / 1000km)	5	3.8	4.1	44.6	41.4	74.3
	10	4.0	4.3	47.1	43.7	78.5
	20	4.3	4.6	50.4	46.8	84.1
	30	4.8	5.1	56.3	52.3	93.9
	40	5.6	6.0	65.6	60.9	109.3
	50	6.6	7.1	77.3	71.8	128.9
	56	7.1	7.7	84.1	78.1	140.1
	60	7.6	8.2	90.0	83.5	149.9
	70	8.9	9.6	105.1	97.6	175.2
	80	10.8	11.6	127.0	117.9	211.6
	90	12.8	13.8	151.3	140.5	252.2

Table E-9 Assumptions for Repair Cost Estimation

Item	Finamcial / Economic Cost	Unit	Car	Taxi	Truck	Large Bus (100 pax.)	Articulated Bus (200pax.)
Vehicle Cost	Financial	R$	15,593	16,630	48,585	129,750	470,000
	Economic	R$	10,853	11,711	39,196	115,848	419,643
Tyre Cost	Financial	R$	520	560	6,810	6,324	11,350
	Economic	R$	321	346	4,204	3,904	7,006
Vehicle Cost w/o Tire	Financial	R$	15,073	16,070	41,775	123,426	458,650
	Economic	R$	10,532	11,366	34,992	111,945	412,637
Annual Repair Cost	% of Vehicle Cost	%	4.0	8.0	8.0	8.0	8.0
	Financial	R$	603	1,286	3,342	9,874	36,692
	Economic	R$	421	909	2,799	8,956	33,011
Annual Operation Distance		Km	24,000	60,000	48,000	75,000	90,000
Average Speed		Km/Hr	30	25	30	25	30
Repair Cost at Average Speed	Financial	R$	25.1	21.4	69.6	131.7	407.7
	Economic	R$	17.6	15.2	58.3	119.4	366.8

Table E-10 Financial and Economic Repair Cost

	Speed (km/hr)	Car	Taxi	Bus (60 pax.)	Large Bus (100 pax.)	Articulated Bus (200pax.)
Repair Cost Rate by Speed	5	141	141	142	142	142
	10	133	133	131	131	131
	20	118	118	111	111	111
	25	112	112	100	100	100
	30	105	105	89	89	89
	35	100	100	82	82	82
	40	95	95	74	74	74
	50	94	94	72	72	72
	60	100	100	79	79	79
	70	108	108	88	88	88
	80	115	115	100	100	100
	90	122	122	112	112	112
Financial Repair Cost (R$ / 1000km)	5	35.4	30.2	99.0	187.2	579.8
	10	33.4	28.5	91.3	172.6	534.5
	20	29.6	25.3	77.4	146.3	453.0
	30	28.0	23.9	69.6	131.7	407.7
	40	26.4	22.5	61.9	117.0	362.4
	50	25.1	21.4	56.9	107.5	332.9
	60	23.9	20.4	51.8	98.0	303.5
	70	23.6	20.1	50.3	95.1	294.4
	80	25.1	21.4	54.9	103.9	321.6
	90	27.1	23.1	61.1	115.6	357.9
Economic Repair Cost (R$/1000Km)	5	24.8	21.4	82.9	169.8	521.7
	10	23.3	20.2	76.5	156.6	480.9
	20	20.7	17.9	64.8	132.7	407.5
	30	19.6	16.9	58.3	119.4	366.8
	40	18.4	15.9	51.8	106.1	326.0
	50	17.6	15.2	47.6	97.5	299.5
	60	16.7	14.4	43.4	88.9	273.1
	70	16.5	14.2	42.1	86.2	264.9
	80	17.6	15.2	46.0	94.2	289.4
	90	19.0	16.4	51.2	104.8	322.0

Table E-11 Assumptions for Depreciation Cost Estimation

	Unit	Car	Taxi	Truck	Large Bus (100 pax.)	Articulated Bus (200pax.)
Vehicle Cost						
Financial	R$	15,593	16,630	48,585	129,750	470,000
Economic	R$	10,853	11,711	39,196	115,848	419,643
Tyre Cost						
Financial	R$	520	560	6,810	6,324	11,350
Economic	R$	321	346	4,204	3,904	7,006
Vehicle Cost w/o Tyre						
Financial	R$	15,073	16,070	41,775	123,426	458,650
Economic	R$	10,532	11,366	34,992	111,945	412,637
Residual Value						
% of Vehicle Cost	%	25.0	10.0	15.0	20.0	20.0
Financial	R$	3,768	1,607	6,266	24,685	91,730
Economic	R$	2,633	1,137	5,249	22,389	82,527
Annual Operation.	Km	24,000	60,000	48,000	75,000	90,000
Average Speed	Km/Hr	30	25	30	25	30
Vehicle Life	Year	12	7	10	7	7
% of Dep. of Use & Time						
Subject to use	%	40	40	70	70	70
Subject to time	%	60	60	30	30	30
Depreciable Amount						
Financial						
subject to use	R$	4,522	5,785	24,856	69,119	256,844
subject to time	R$	6,783	8,678	10,653	29,622	110,076
Total	R$	11,305	14,463	35,509	98,741	366,920
Economic						
subject to use	R$	3,160	4,092	20,820	62,689	231,077
subject to time	R$	4,740	6,137	8,923	26,867	99,033
Total	R$	7,899	10,229	29,743	89,556	330,109

Table E-12 Financial and Economic Depreciation Cost Subject to Use

	Speed (Km/hour)	Car	Taxi	Bus (60 pax.)	Large Bus (100 pax.)	Articulated Bus (200pax.)
Indices for Depreciation Cost subject to Use (Av. Speed = 100)	5	136	136	131	131	131
	10	130	130	123	123	123
	20	119	119	108	108	108
	25	114	114	100	100	100
	30	108	108	92	92	92
	35	100	100	81	81	81
	40	100	100	81	81	81
	50	100	100	80	80	80
	60	104	104	84	84	84
	70	110	110	91	91	91
	80	116	116	99	99	99
	90	121	121	109	109	109
Financial Deprcation Cost subject to Use (R$/1000km)	5	21.4	18.8	67.7	172.2	533.3
	10	20.4	17.9	63.8	162.3	502.4
	20	18.6	16.4	56.0	142.3	440.7
	30	17.8	15.6	51.8	131.7	407.7
	40	17.0	14.9	47.6	121.0	374.6
	50	15.7	13.8	42.0	106.7	330.6
	60	15.7	13.8	41.7	106.0	328.4
	70	15.7	13.8	41.4	105.3	326.2
	80	16.4	14.3	43.7	111.0	343.8
	90	17.3	15.2	47.0	119.6	370.2
Economic Depreciation Cost subject to Use (R$/1000km)	5	15.0	13.3	56.7	156.2	479.8
	10	14.3	12.7	53.5	147.2	452.0
	20	13.0	11.6	46.9	129.1	396.5
	30	12.5	11.1	43.4	119.4	366.8
	40	11.9	10.6	39.9	109.7	337.0
	50	11.0	9.7	35.2	96.8	297.4
	60	11.0	9.7	34.9	96.2	295.4
	70	11.0	9.7	34.7	95.5	293.4
	80	11.4	10.1	36.6	100.7	309.3
	90	12.1	10.8	39.4	108.4	333.1

Table E-13 Depreciation Cost Subject to Time

	Unit	Car	Taxi	Truck	Large Bus (100 pax.)	Articulated Bus (200pax.)
Financial Cost						
Daily Cost	R$/Day	1.55	3.40	2.92	11.59	43.08
Hourly Cost	R$/Hr	0.71	0.52	0.67	1.41	5.24
Economic Cost						
Daily Cost	R$/Day	1.08	2.40	2.44	10.52	38.76
Hourly Cost	R$/Hr	0.49	0.37	0.56	1.28	4.72

Table E-14 Capital Opportunity Cost by Type of Vehicle

	Unit	Car	Taxi	Truck	Large Bus (100 pax.)	Articulated Bus (200pax.)
Vehicle Cost						
Financial	R$	15,593	16,630	48,585	129,750	470,000
Economic	R$	10,853	11,711	39,196	115,848	419,643
Tyre Cost						
Financial	R$	520	560	6,810	6,324	11,350
Economic	R$	321	346	4,204	3,904	7,006
Vehicle Cost w/o Tyre						
Financial	R$	15,073	16,070	41,775	123,426	458,650
Economic	R$	10,532	11,366	34,992	111,945	412,637
Resiodual Value						
% of Vehicle Cost	%	25.0	10.0	15.0	15.0	10.0
Financial	R$	3,768	1,607	6,266	18,514	45,865
Economic	R$	2,633	1,137	5,249	16,792	41,264
Annual Operation.	Km	24,000	60,000	48,000	75,000	90,000
Average Speed	Km/Hr	30	25	30	25	30
Vehicle Life	Year	12	7	10	7	7
Interest rate(i = 12%)		0.12	0.12	0.12	0.12	0.12
Capital Opprtunity Cost						
Financial	R$/Day	3.10	2.91	7.90	23.33	82.93
	R$/Hr	1.41	0.44	1.80	2.84	10.09
Economic	R$/Day	2.16	2.06	6.61	21.16	74.61
	R$/Hr	0.99	0.31	1.51	2.57	9.08

Table E-15 Crew Cost and Overhead Cost by Type of Vehicle

	Unit	Car	Taxi	Truck	Large Bus (100 pax.)	Articulated Bus (200pax.)
Annual Crew Cost						
Financial	R$	0	7,150	13,650	14,950	14,950
Economic	R$	0	5,363	10,238	11,213	11,213
Annul Overhead Cost						
Financial	R$	0	358	1,365	2,990	2,990
Economic	R$	0	268	1,024	2,243	2,243
Daily Crew and OH Cost						
Financial	R$	0.00	20.57	41.14	49.15	49.15
Economic	R$	0.00	15.43	30.85	36.86	36.86
Hourly Crew and OH Cost						
Financial	R$	0.00	3.13	9.38	5.98	5.98
Economic	R$	0.00	2.35	7.04	4.49	4.49

Table E-16 Aggregate Vehicle Operating Coat by Type of Vehicle

(1) VOC subject to Use

	Speed (Km/hour)	Car	Taxi	Truck	Large Bus (100 pax.)	Articulated Bus (200pax.)
Financial Cost (R$/1000km)	5	564.4	837.6	2,154.9	1,666.7	2,692.4
	10	387.1	563.1	1,457.4	1,199.3	2,097.7
	20	291.1	417.3	1,100.8	937.2	1,703.4
	30	258.1	367.2	865.6	869.2	1,580.0
	40	240.8	341.4	758.8	821.5	1,483.8
	50	235.6	334.3	723.3	849.7	1,482.0
	60	241.2	343.5	710.9	922.5	1,553.3
	70	252.4	361.1	734.7	1,023.4	1,669.5
	80	272.4	390.1	805.4	1,160.3	1,871.2
	90	300.2	430.6	905.0	1,293.4	2,086.1
Economic Cost (R$/1000km)	5	417.8	619.2	1,750.3	1,384.0	2,271.6
	10	285.6	415.4	1,179.1	997.9	1,776.7
	20	214.1	307.3	886.1	778.0	1,440.2
	30	189.5	270.1	691.8	718.3	1,329.5
	40	176.5	250.8	601.2	674.1	1,239.4
	50	172.5	245.4	568.1	691.6	1,225.6
	60	176.6	252.2	555.7	748.3	1,277.8
	70	184.8	265.0	573.3	829.0	1,368.9
	80	199.3	286.2	626.3	937.8	1,529.6
	90	219.5	315.6	700.7	1,042.0	1,698.8

(2) VOC subject to Time

	Car	Taxi	Truck	Large Bus (100 pax.)	Articulated Bus (200pax.)
Financial Cost					
Depreciation	0.707	0.517	0.666	1.411	5.242
Capital Opportunity Cost	1.413	0.442	1.802	2.839	10.090
Crew and Overhead Cost	0.000	3.128	9.384	5.980	5.980
Total	2.120	4.087	11.852	10.229	21.312
Economic Cost					
Depreciation	0.494	0.365	0.558	1.279	4.716
Capital Opportunity Cost	0.987	0.313	1.509	2.575	9.078
Crew and Overhead Cost	0.000	2.346	7.038	4.485	4.485
Total	1.481	3.024	9.105	8.339	18.279

Table E-17 Cost Benefit Flow for Economic Evaluation

(1) Entire Projects

Year	Invest-	Mainte-	Benefit	Net Cash
2004	77.5			-77.5
2005	84.8			-84.8
2006	202.5			-202.5
2007	34.3	1.5	97.3	61.5
2008	71.1	1.5	125.9	53.3
2009	85.3	1.5	163.1	76.3
2010	68.2	1.5	211.2	141.5
2011	23.6	1.5	280.9	255.7
2012	39.2	3.5	285.4	242.8
2013		3.5	250.9	247.4
2014		3.5	220.6	217.1
2015		3.5	193.9	190.4
2016		3.5	170.4	166.9
2017		3.5	149.8	146.3
2018		3.5	131.7	128.2
2019		3.5	115.8	112.3
2020		3.5	101.8	98.3
2021		3.5	89.5	86.0
2022		7.0	78.7	71.7
2023		7.0	69.1	62.1
2024		7.0	60.8	53.8
2025		7.0	53.4	46.4
2026	-1.2	7.0	47.0	41.2
2027		5.5	41.3	35.8
2028		5.5	36.3	30.8
2029		5.5	31.9	26.4
2030		5.5	28.0	22.6
2031		5.5	24.7	19.2

IRR (%)	28.0
NPV (R$ million)	495.3
B/C	1.97

(2) Trunk Busway System

（R$ million)

Year	Invest-ment	Mainte-	Benefit	Net Cash
2004	44.6			-44.6
2005	46.6			-46.6
2006	121.3			-121.3
2007	25.7	1.5	40.8	13.6
2008	12.7	1.5	42.2	28.0
2009	17.3	1.5	43.7	24.8
2010	8.8	1.5	45.2	34.9
2011		1.5	60.1	58.6
2012		1.5	62.0	60.5
2013		1.5	61.8	60.3
2014		1.5	61.7	60.2
2015		1.5	61.6	60.0
2016		1.5	61.4	59.9
2017		3.0	61.3	58.3
2018		3.0	61.2	58.1
2019		3.0	61.0	58.0
2020		3.0	60.9	57.8
2021		3.0	60.7	57.7
2022		3.0	60.6	57.6
2023		3.0	60.5	57.4
2024		3.0	60.3	57.3
2025		3.0	60.2	57.2
2026	-1.2	3.0	60.1	58.3

IRR (%)	17.0
NPV (R$ million)	84.9
B/C	1.36

(3) Entire Road Project

（R$ million)

Year	Invest-ment	Mainte-	Benefit	Net Cash
2004	32.9			-32.9
2005	38.2			-38.2
2006	81.1			-81.1
2007	8.6		64.6	56.0
2008	58.4	1.5	88.9	28.9
2009	68.0	1.5	120.8	51.4
2010	59.4	1.5	168.1	107.2
2011	23.6	1.5	223.5	198.4
2012	39.2	1.5	233.4	192.8
2013		1.5	191.8	190.3
2014		1.5	157.5	156.0
2015		1.5	129.4	127.9
2016		1.5	106.3	104.8
2017		3.0	87.3	84.3
2018		3.0	71.7	68.7
2019		3.0	58.9	55.9
2020		3.0	48.4	45.4
2021		3.0	39.8	36.7
2022		3.0	32.7	29.6
2023		3.0	26.8	23.8
2024		3.0	22.1	19.0
2025		3.0	18.1	15.1
2026		3.0	14.9	11.8
2027		3.0	12.2	9.2
2028		3.0	10.0	7.0
2029		3.0	8.2	5.2
2030		3.0	6.8	3.7
2031		3.0	5.6	2.5

IRR (%)	41.0
NPV (R$ million)	429.2
B/C	2.53

(4) Marinha

Year	Invest-	Mainte-	Benefit	Net Cash
2004	0.0			0.0
2005	0.0			0.0
2006	3.3			-3.3
2007	3.3			-3.3
2008	0.0			0.0
2009	0.0			0.0
2010	0.0			0.0
2011	0.0			0.0
2012	25.9		1.6	-24.3
2013		0.20	20.9	20.7
2014		0.20	23.1	22.9
2015		0.20	25.5	25.3
2016		0.20	28.2	28.0
2017		0.20	31.2	31.0
2018		0.20	34.4	34.2
2019		0.20	38.1	37.9
2020		0.20	15.0	14.8
2021		0.20	14.3	14.1
2022		0.20	13.6	13.4
2023		0.41	13.0	12.6
2024		0.41	12.4	12.0
2025		0.41	11.8	11.4
2026		0.41	11.3	10.8
2027		0.41	10.7	10.3
2028		0.41	10.2	9.8
2029		0.41	9.8	9.4
2030		0.41	9.3	8.9
2031		0.41	8.9	8.5

IRR (%)		37.9
NPV (R$ million)		49.2
B/C		4.05

(5) Yamada

Year	Invest-	Mainte-	Benefit	Net Cash
2004	0.0			0.0
2005	5.3			-5.3
2006	5.3			-5.3
2007	5.3			-5.3
2008	0.0			0.0
2009	0.0			0.0
2010	22.8			-22.8
2011	23.6			-23.6
2012	13.2		0.8	-12.4
2013		1.5	11.4	9.9
2014		1.5	12.9	11.4
2015		1.5	14.5	13.0
2016		1.5	16.4	14.9
2017		1.5	18.6	17.0
2018		3.0	21.0	17.9
2019		3.0	23.7	20.6
2020		3.0	26.8	23.7
2021		3.0	30.2	27.2
2022		3.0	34.1	31.1
2023		3.0	38.6	35.5
2024		3.0	43.6	40.5
2025		3.0	49.2	46.2
2026		3.0	55.6	52.6
2027		3.0	62.8	59.8
2028		3.0	71.0	67.9
2029		3.0	80.2	77.1
2030		3.0	90.6	87.5
2031		3.0	102.3	99.3

IRR (%)	18.0
NPV (R$ million)	37.6
B/C	1.80

(6) Dezembro

Year	Invest-	Mainte-	Benefit	Net Cash
2004	8.8			-8.8
2005	8.8			-8.8
2006	8.8			-8.8
2007	0.0			0.0
2008	35.9			-35.9
2009	37.1			-37.1
2010	20.8			-20.8
2011		0.45	150.8	150.3
2012		0.45	173.8	173.4
2013		0.45	162.4	161.9
2014		0.45	151.7	151.2
2015		0.45	141.7	141.2
2016		0.45	132.3	131.9
2017		0.45	123.6	123.2
2018		0.45	115.5	115.0
2019		0.45	107.9	107.4
2020		0.45	32.6	32.2
2021		0.90	26.5	25.6
2022		0.90	21.5	20.6
2023		0.90	17.4	16.5
2024		0.90	14.1	13.2
2025		0.90	11.5	10.6
2026		0.90	9.3	8.4
2027		0.90	7.5	6.6
2028		0.90	6.1	5.2
2029		0.90	5.0	4.1
2030		0.90	4.0	3.1
2031		0.90	3.3	2.4

IRR (%)		45.2
NPV (R$ million)		330.7
B/C		5.12

(7) Independencia

Year	Invest-	Mainte-	Benefit	Net Cash
2004	24.1			-24.1
2005	24.1			-24.1
2006	63.7			-63.7
2007	0.0	0.6	67.4	66.9
2008	22.5	0.6	69.8	46.7
2009	30.8	0.6	72.2	40.9
2010	15.7	0.6	76.8	60.6
2011		0.6	102.2	101.7
2012		0.9	120.2	119.3
2013		0.9	96.5	95.6
2014		0.9	77.5	76.6
2015		0.9	62.2	61.3
2016		0.9	49.9	49.1
2017		1.4	40.1	38.7
2018		1.4	32.2	30.8
2019		1.4	25.8	24.4
2020		1.4	20.8	19.3
2021		1.4	16.7	15.2
2022		1.8	13.4	11.6
2023		1.8	10.7	9.0
2024		1.8	8.6	6.9
2025		1.8	6.9	5.2
2026		1.8	5.6	3.8
2027		1.8	4.5	2.7
2028		1.8	3.6	1.8
2029		1.8	2.9	1.1
2030		1.8	2.3	0.6
2031		1.8	1.9	0.1

IRR (%)	42.8
NPV (R$ million)	247.8
B/C	2.75