22.3. EVALUATION OF SHORT-TERM PROJECTS

The hourly travel demand is analyzed in the morning peak hour in 2010 in the "with and without" cases. From the peak hour analyses, the public transport service conditions such as travel time, operated bus fleets and total proceeds, are disclosed. In 2010, it is assumed that the fare system of public transport is independent by each mode as a period of transition to the integrated fare system. In this analysis, the proposed fare system, which is the integrated fare system, is not applied in the traffic demand analysis.

In the fare system in 2010, the following fare rate is applied.

a) Conventional bus: S./1.0
b) Trunk Bus: S./1.5
c) Railway: S./1.5
d) To establish a fare rate of each public transport mode for transfer between public transport

22.3.1. PASSENGER DEMAND ON PUBLIC TRANSPORT

Passenger demands on the public transport in the morning peak hour in 2010 are shown in Figure 22.3-1 to Figure 22.3-3. In Figure 22.3-1 which shows the traffic volumes in 2010, the figure in the upper row shows the traffic demand in the "without" case in which future OD trips are assigned on the present transport network. The bottom figures show the traffic demand in the "with" case in which future OD trips are assigned on Master Plan networks. Figure 22.3-2 shows the hourly passenger volumes in 2010 on the trunk busway and railway. In the upper side figure, the hourly railway passenger volumes are shown in green and the hourly trunk bus passenger volumes are shown in red. In the bottom, the conventional bus passengers are shown. Figure 22.3-3 shows the passenger volumes in 2004 in the upper row and the bottom row shows the volumes in 2025, which is without the Master Plan case.

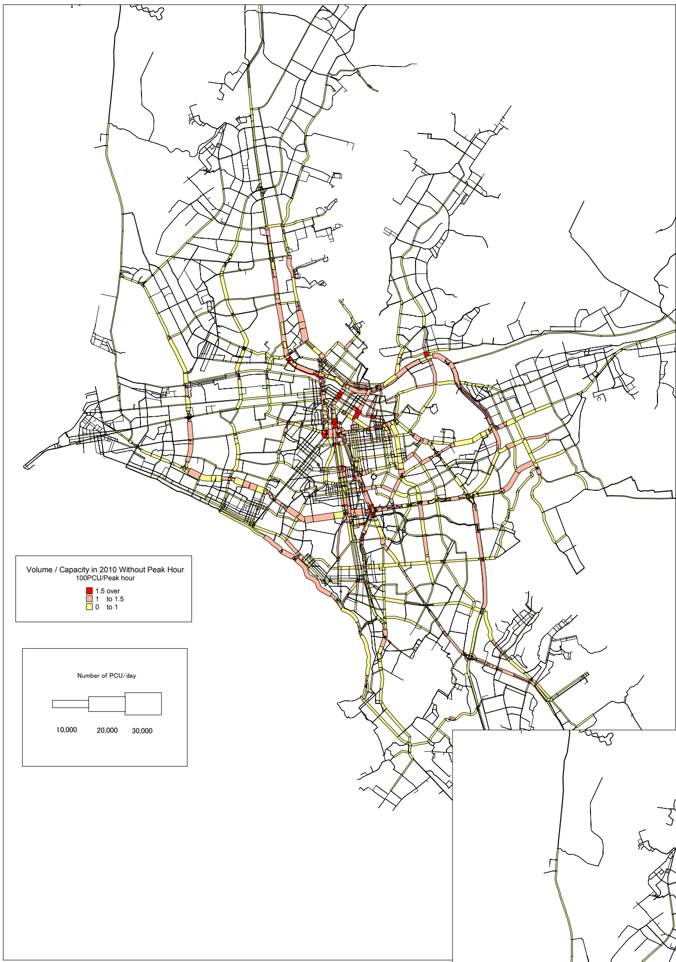
Table 22.3-1 shows the total number of passengers per hour on the public transport by mode, which is the total number of public transport users, not the flow rate on transport lines. In the "without" case in 2010, the conventional bus passengers will increase 1.12 times in comparison to the volume in 2004, in contrast to 0.69 times in the "with" case due to that the public transport passengers divert to the trunk bus and railway system. Since those mass transit systems don't occupy traffic lanes on roads, the traffic congestion on the roads will be alleviated.

Table 22.3-1 Hourly Number of Public Transport Passengers By Mode

(Unit: Passengers/hour)

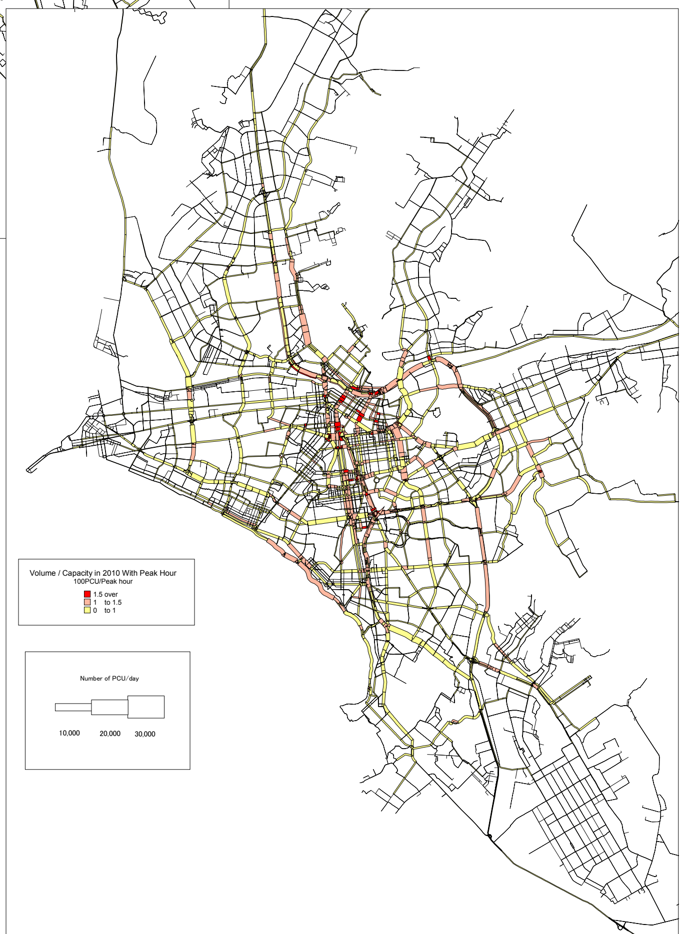
Mode	2004	2010			2010/2004		2010
		With	Without	With/Without	with	without	Composition Ratio of With
Conventional Bus	1,512,716	1,037,810	1,698,947	0.61	0.69	1.12	0.64
Trunk Bus	-	416,828	-	-	-	-	0.26
Train	-	171,998	-	-	-	-	0.11
Total	1,512,716	1,626,636	1,698,947	0.96	1.08	1.12	1.00

Note: Trip means a trip is counted every transfer, when a passenger transfers from one mode to another.



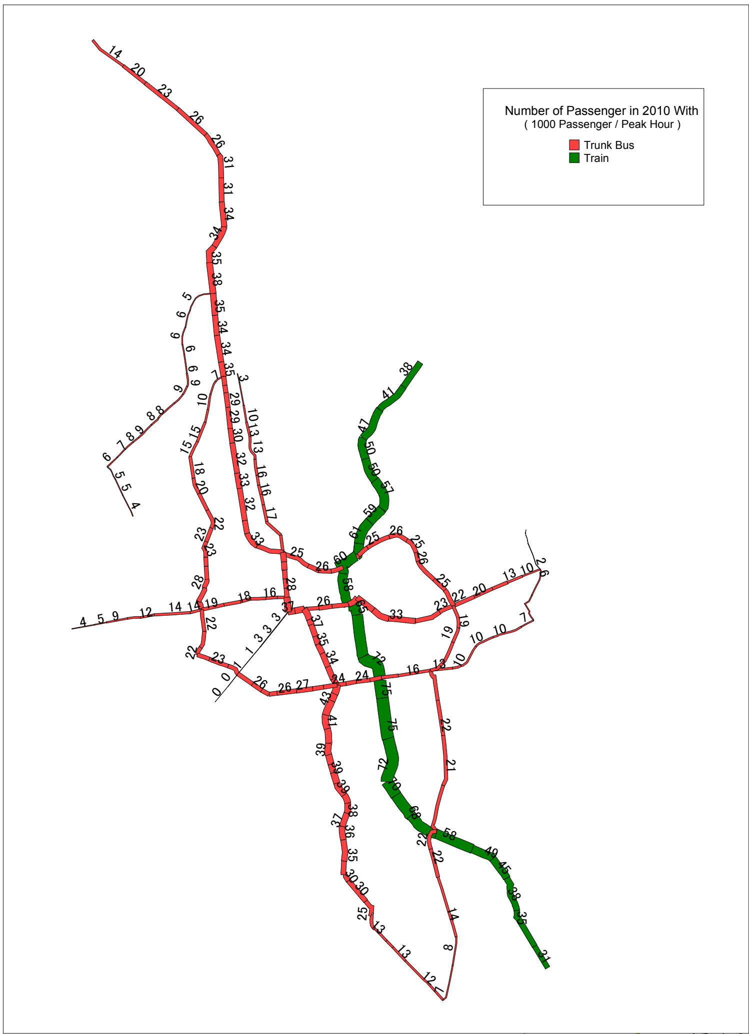
2004 Network/2010 Peak OD:

Without Case

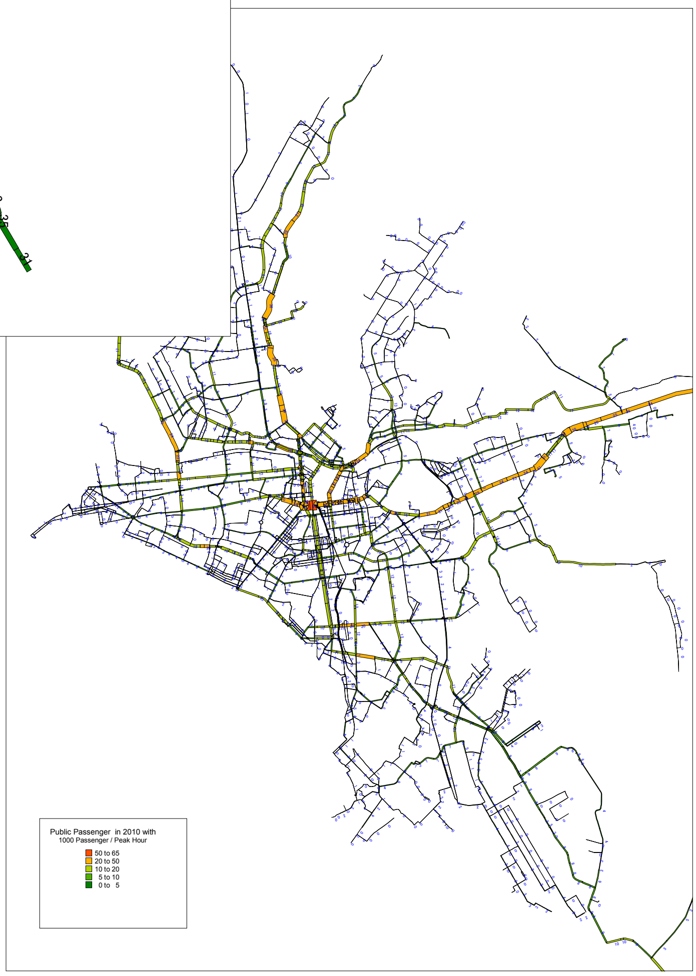


With Case

Figure 22.3-1 Peak Hour Traffic Demand of All Modes (2004 Network/2025 Peak OD: Without Case for Upper Row, and 2025 Network/2025 Peak OD Table: With Case for Bottom Row)

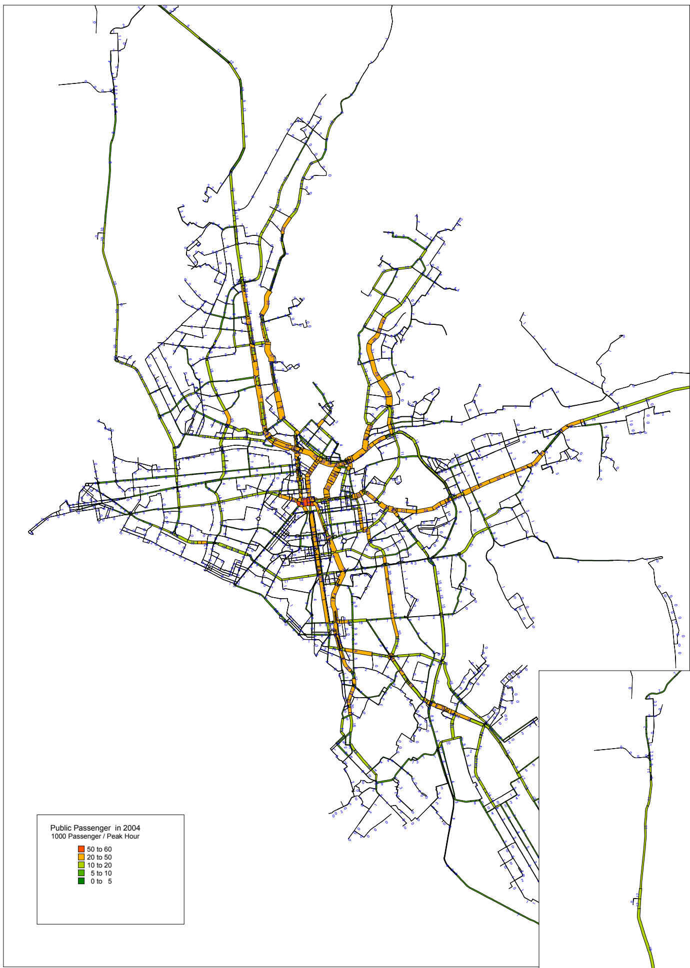


Trunk and Railway Transport Passengers

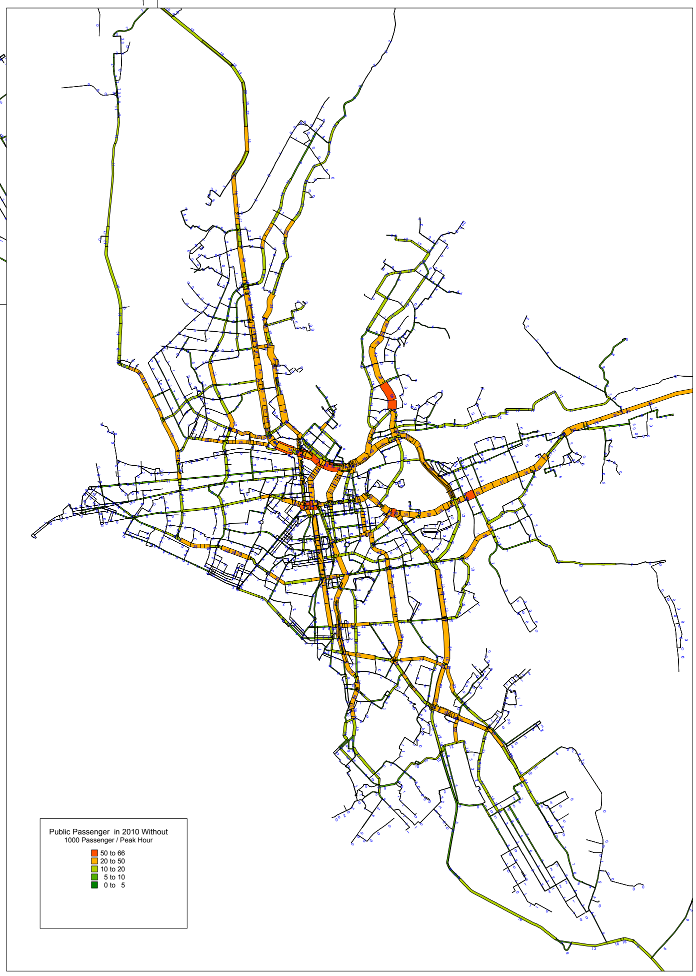


Conventional Bus Passengers

Figure 22.3-2 Peak Hour Traffic Demand by Trunk and Railway Transport for Upper Row and by Conventional Bus for Bottom Row (2010 Network/2010 Peak OD)



2004 Public Transport Passengers



2010 Public Transport Passengers (Without Case)

Figure 22.3-3 2004 Peak Hour Traffic Demand of Public Transport for Upper Row, and 2010 Peak Hour Traffic Demand (Without Case) for Bottom Row

22.3.2. SHORTENING OF COMMUTER HOUR

(1) Average Travel Time

Table 22.3-2 shows the total and average travel times of the public transport passengers in the peak hour. The average travel time in 2010 in terms of total travel time per trip is slightly increased. The average travel time in the “with” case is 49 minutes, in contrast to 45 minutes at the present. In the “without” cases, the average travel time is approximately 56 minutes. Its figure is 1.25 times that of the present. The average travel time in the “with” case maintains the present level. On the other hand, the average travel distance increases in the future due to the growing number of residents living in the suburbs, as shown in Table 22.3-3. Moreover, future traffic and transport volumes increase at 1.1 times that of the present.

Taking those conditions into account, the introduction of the mass transit system serves to improve the travel time of the public transport passenger. The mass transit system is expected to reduce the average travel time in comparison to that in the “without” case.

Table 22.3-2 Total Travel Time and Average Travel Time in the Peak Hour

(Unit: hour)

Mode	2004	2010			2010/2004	
		With	Without	With/Without	With	Without
Conventional Bus	553,635	467,049	790,381	0.59	-	-
Trunk Bus	-	163,277	-	-	-	-
Train	-	61,635	-	-	-	-
Total	553,635	691,961	790,381	0.88	1.25	1.42
Average Travel Time (min)	44.9	49.4	56.0	0.88	1.10	1.25

Table 22.3-3 Average Travel Distance by Years

Item	2004	2010	2025
Travel Distance (km)	12.3	15.9	19.0

22.3.3. DECREASE OF NUMBER OF OPERATED FLEETS

Table 22.3-4 shows the total numbers of operated bus fleets and railway coaches in the peak hour. In the rapid mass transit system, the large articulated bus fleets and railway coaches are introduced. The total operated fleets in 2010 are approximately 7,040 fleets/hour, equivalent to 0.9 times of the present.

Table 22.3-4 Total Numbers of Operated Fleets and Coaches in the Peak Hour

(Unit: Number of Fleets/hour)

Mode	2004	2010			2010/2004	
		With	Without	With/Without	With	Without
Conventional Bus	7,567	5,942	9,920	0.60	0.79	1.67
Trunk Bus	-	1,046	-	-	-	-
Train	-	50	-	-	-	-
Total	7,567	7,038	9,920	0.71	0.93	1.67

22.3.4. NUMBER OF OPERATED FLEETS ON EACH LINE

Table 22.3-5 shows the number of service frequencies and passengers by transport line in the peak hour. Figure 22.3-4 to Figure 22.3-7 show the tentative plans of each line configuration of the mass transit in exclusive of BT7011 and BT7012 for railway line, and BC2021 and BC2022 for the COSAC-1 line, shown in Chapter 21. The detailed line configuration plan must carry out further studies.

As can be seen, the total passengers in the railway line No. BT7011 and BT7012 (inbound and outbound directions in the north-south line) are approximately 78,000 and 94,000 passengers/hour, respectively. The frequencies in each direction are 25 times/hour which are equivalent to a minimum headway of 2.5 minutes in each direction.

As for the trunk bus lines, the total passengers in the trunk bus line No. BC2021 and BC2022 (COSAC-1) are approximately 48,000 and 55,000 passengers/hour, respectively. The frequencies are 110 and 120 times/hour, which are equivalent to a minimum headway of 30 seconds in each direction.

Table 22.3-5 Number of Service Frequencies and Passengers by Line in the Peak Hour

Project		Line No.	Project Size (km)	Frequency (Times/hour)	Headway (min)	Total Passengers /hour	Project Type
No.	Name						
TP-02	Line-1 (2)	BT7011	38.0	24	2.5	77,530	Railway
TP-03	Line-1 (3)	BT7012	37.9	26	2.3	94,468	
BP-01	Av. Grau	BC2011	14.3	106	0.6	29,938	Trunk Bus
BP-03	Carretera Central	BC2012	14.3	75	0.8	22,217	
BP-02	COSAC Project	BC2021	45.6	108	0.6	48,433	
		BC2022	45.7	118	0.5	55,167	
BP-04	Av. Venezuela	BC2031	15.3	32	1.9	9,870	
		BC2032	15.3	40	1.5	11,693	
BP-05	Av. Brasil	BC2041	8.5	5	12.0	1,267	
		BC2042	8.5	12	5.0	3,363	
BP-08	Universitaria Sur	BC2081	24.1	21	2.9	5,511	
		BC2082	24.1	11	5.5	2,596	
BP-09	Av. Callao-Canta	BC2071	15.6	30	2.0	10,408	
		BC2072	15.6	19	3.2	6,565	
BP-11	Av. Javier Prado	BC2091	49.4	79	0.8	38,823	
		BC2092	49.5	62	1.0	28,347	
BP-12	Av. Panamericana Norte	BC2061	45.1	111	0.5	38,732	
		BC2062	44.9	70	0.9	24,859	
BP-13	Av. Panamericana Sur	BC2051	44.5	59	1.0	35,209	
		BC2052	44.4	88	0.7	43,830	
Total			600.7				

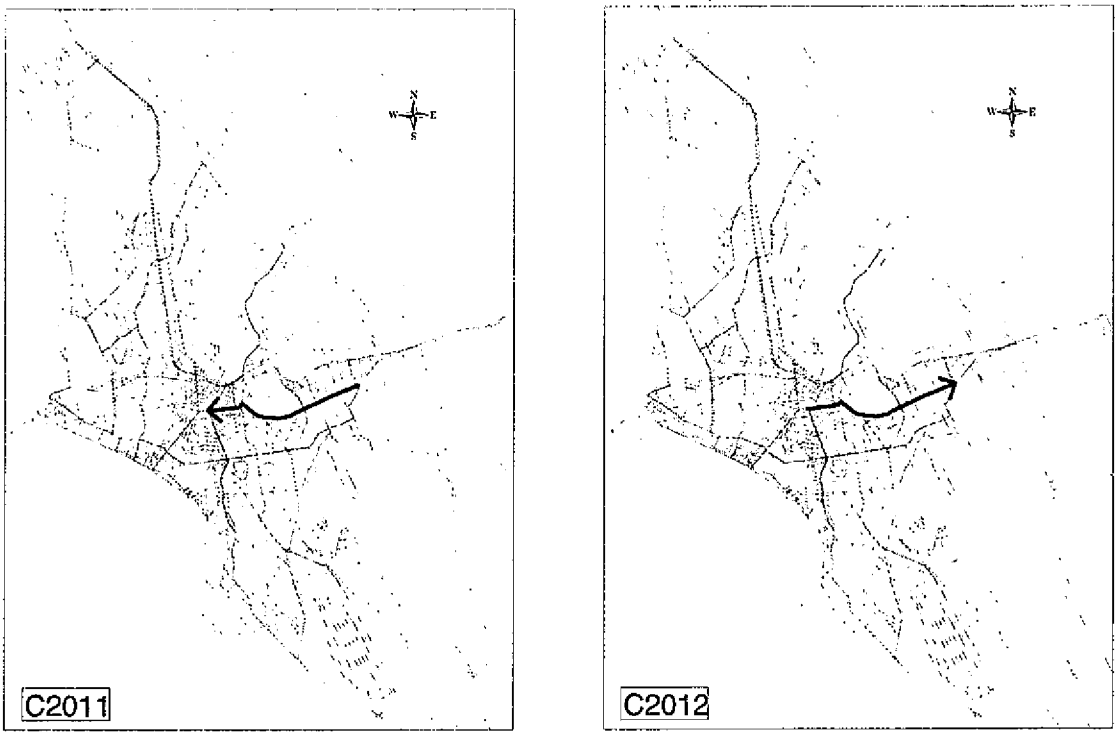


Figure 22.3-4 Line Configurations of BC2011 and 2012 in Trunk Bus (BP-01 and 03)

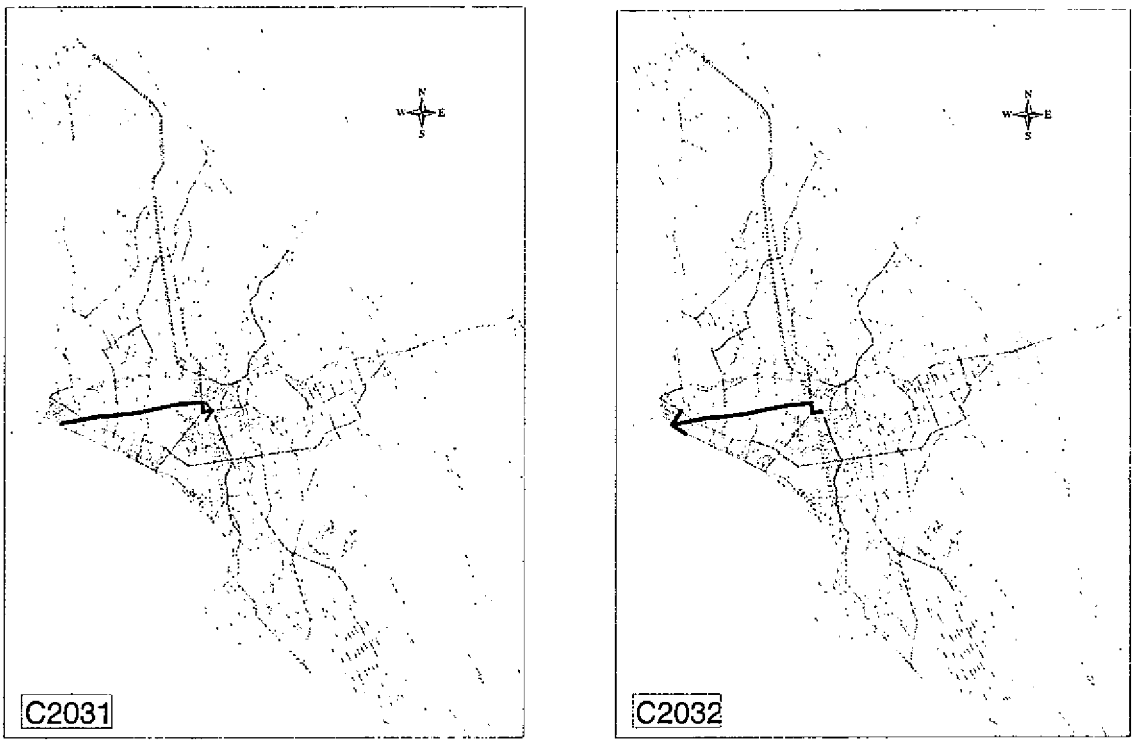


Figure 22.3-5 Line Configurations of BC2031 and 2032 in Trunk Bus (BP-04)

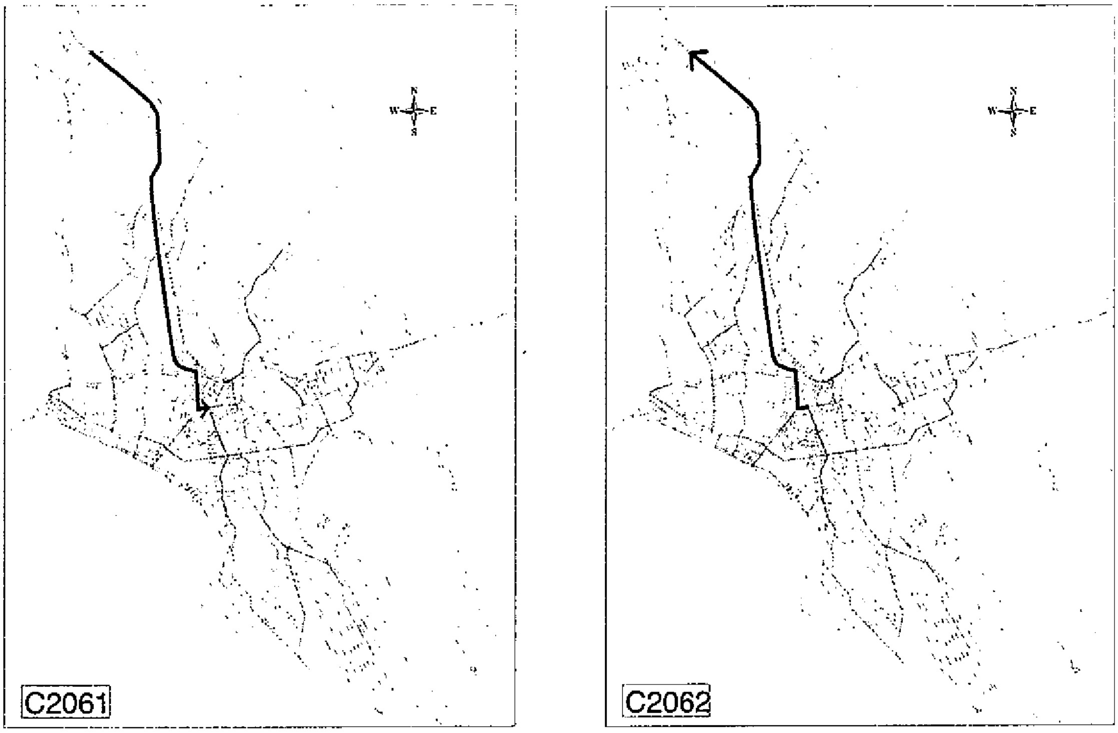


Figure 22.3-6 Line Configurations of BC2061 and 2062 in Trunk Bus (BP-12)

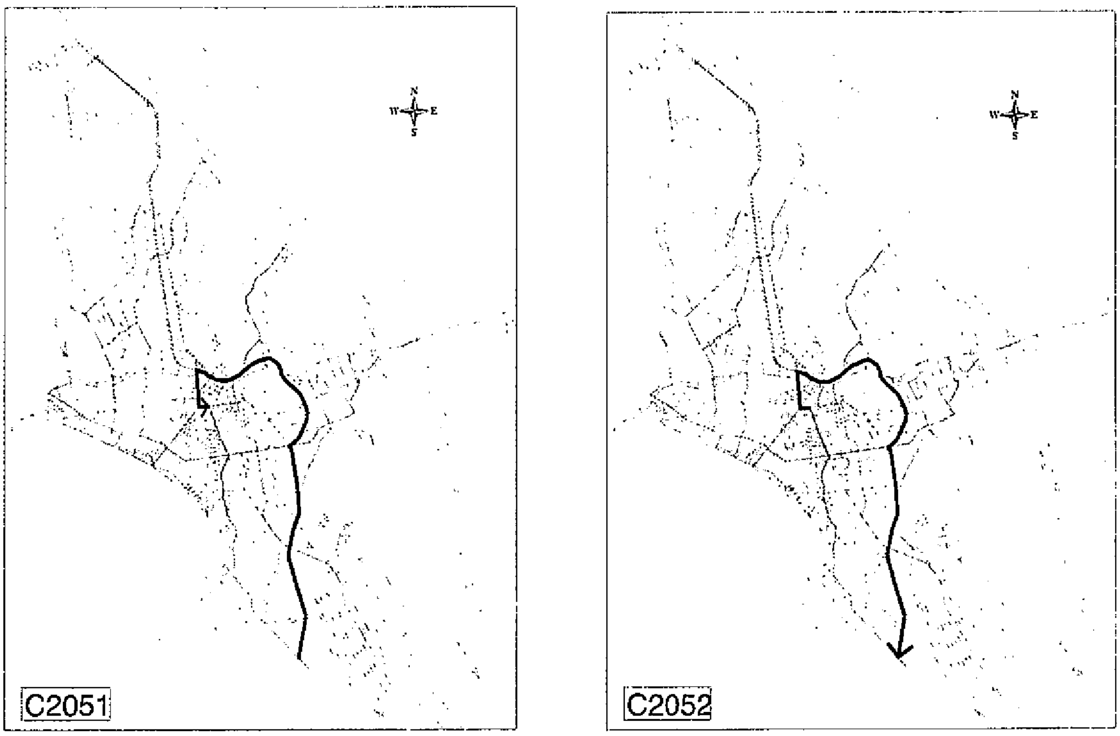


Figure 22.3-7 Line Configurations of BC2051 and 2052 in Trunk Bus (BP-13)

22.3.5. CHANGE OF TOTAL PROCEEDS

Table 22.3-6 shows the total fare proceeds from the public transport system in the peak hour under the isolated fare system mentioned above. Total proceeds in the whole study area will increase at 1.3 times in comparison to the present value. The fare rate per passenger is increased to S./2.3 in 2010, equivalent to 1.1 times the present rate. This is due to the fact that the transfer times increase in 2010 under the mass transit system.

Table 22.3-6 Total Fare Proceeds in the Peak Hour

Items	2004	2010			2010/2004	
		With	Without	With/Without	With	Without
Total Trips / Hour	741,814	841,103	846,276	0.99	1.13	1.14
Unlinked Trips /Hour	1,512,716	1,626,636	1,698,947	0.96	1.08	1.12
Total Proceeds (soles/hour)						
Conventional Bus	1,512,716	1,037,810	1,698,947	0.61		
Trunk Bus	0	625,242	-	-	-	-
Train	0	257,997	-	-	-	-
Total	1,512,716	1,921,049	1,698,947	1.13	1.27	1.12
Fare/Trip (soles)	1.0	1.2	1.0	1.18	1.18	1.00
Fare/Passenger (Soles)	2.0	2.3	2.0	1.14	1.12	0.98

22.3.6. IMPROVEMENT OF TRAFFIC CONDITIONS

(1) Average Travel Speed and Volume-Capacity Ratio

Table 22.3-7 shows the average travel speed and volume-capacity ratio on roads. Under the proposed railway and trunk bus system, since the trunk bus runs on the median of the roadway and only conventional buses run on the traffic lanes with mixed traffic, the conventional bus is influenced by traffic congestion on the roads. In 2010, the total number of operated conventional buses decreases 0.8 times in comparison to the present number. This serves to alleviate traffic and transport congestion on roads. The traffic congestion level in 2010 in terms of volume-capacity ratio over 1.0 is the same as that at the present. This is because the decrease of conventional buses and the increase of the private mode will balance in 2010.

The travel speed in 2010is also the same as that at the present. In the “without” case, the speed decreases to 14km/h. In 2010, the average travel speed will be maintained at the present level.

Table 22.3-7 Average Travel Speed and Volume-Capacity on Roads in 2010

Items	2004	2010			2010/2004	
		With	Without	With/Without	With	Without
Average Travel Speed (km/h)	16.8	16.8	14.3	1.17	1.00	0.85
Volume-Capacity Ratio						
V/C < 1.0	92.1%	92.2%	89.3%	1.02	0.99	0.97
1.0 =< V/C < 1.5	7.4%	7.0%	9.6%	0.73	0.95	1.30
V/C > 1.5	0.5%	0.8%	1.1%	0.67	1.47	2.20

(2) Traffic Impacts on Major Roads Parallel to the Mass Transit Lines

With the construction of the mass transit system, the operated number of conventional buses decreases in the whole study area. Especially, the conventional buses on roads parallel to the mass transit lines considerably decrease in as a result of diversion to the mass transit system. However, in order to increase the number of future private vehicles, the total traffic volume on the roads will increase.

Figure 22.3-8 to Figure 22.3-12 show traffic volumes on major roads parallel to the mass transit lines in which the total traffic volume, the conventional bus volume and the total passengers of public transport are shown in 2004 and 2010. Figure 22.3-13 shows the location of those roads. Av. Tupac Amaru, Av. Universitaria and Av. Los Próceres de La Independencia have the mass transit plan on the median, while Av. Arequipa and Av. Oscar R. Benavides do not have the mass transit plan on those roads. When comparing the indices of 2004 and the "with" case in 2010, the passengers on the roads with the mass transit system increase in 2010, while the passengers on the roads without plans decrease. The traffic volumes on those roads in 2010 increase slightly. The conventional bus volume in 2010 decreases, especially on Av. Los Próceres de La Independencia.

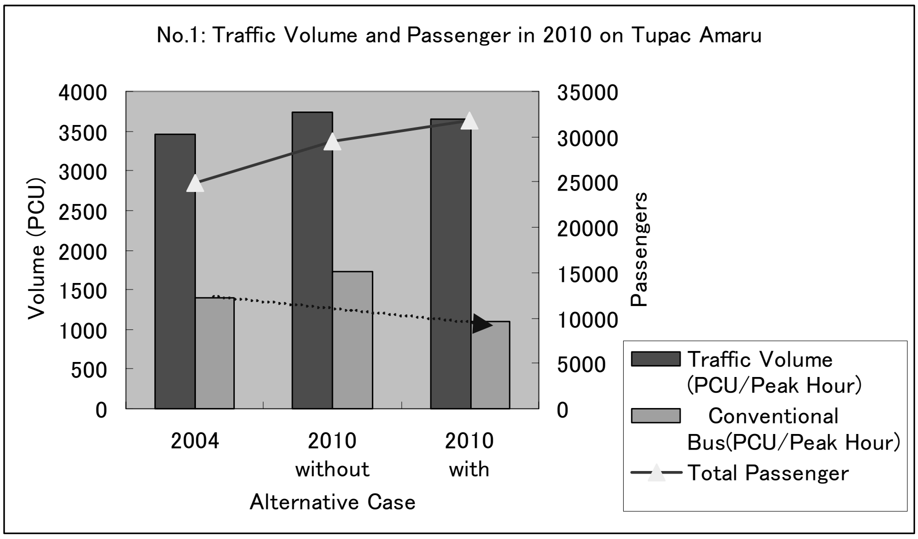


Figure 22.3-8 Traffic Volumes on Av. Tupac Amaru Parallel to the Mass Transit Lines

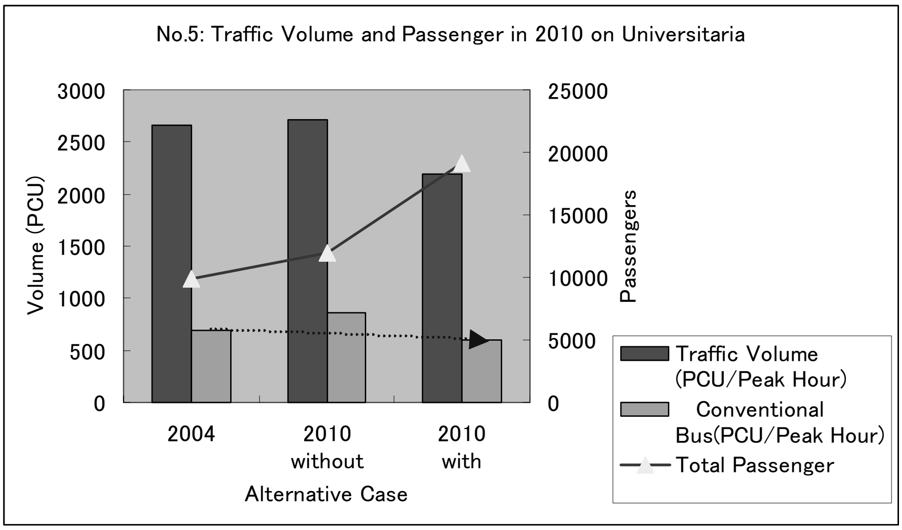


Figure 22.3-9 Traffic Volumes on Av. Universitaria Parallel to the Mass Transit Lines

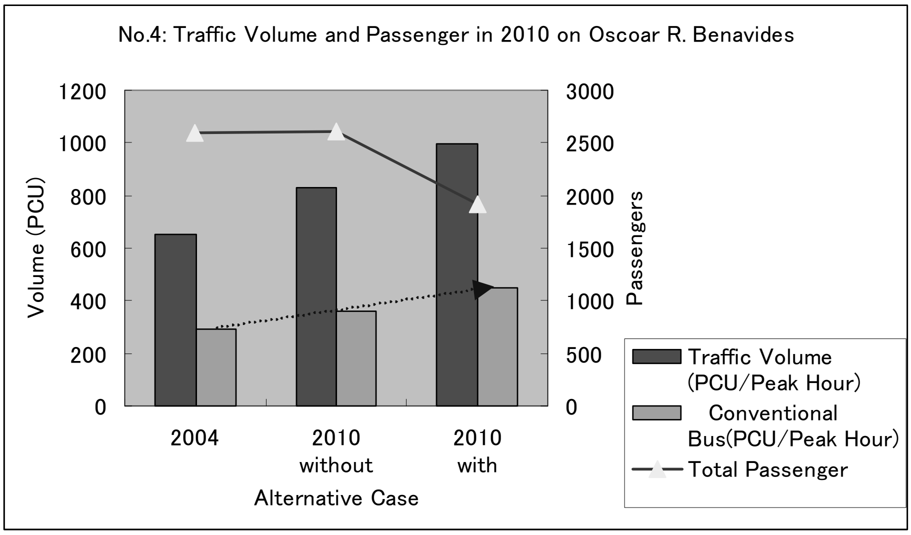


Figure 22.3-10 Traffic Volumes on Av. Oscar R. Benavides

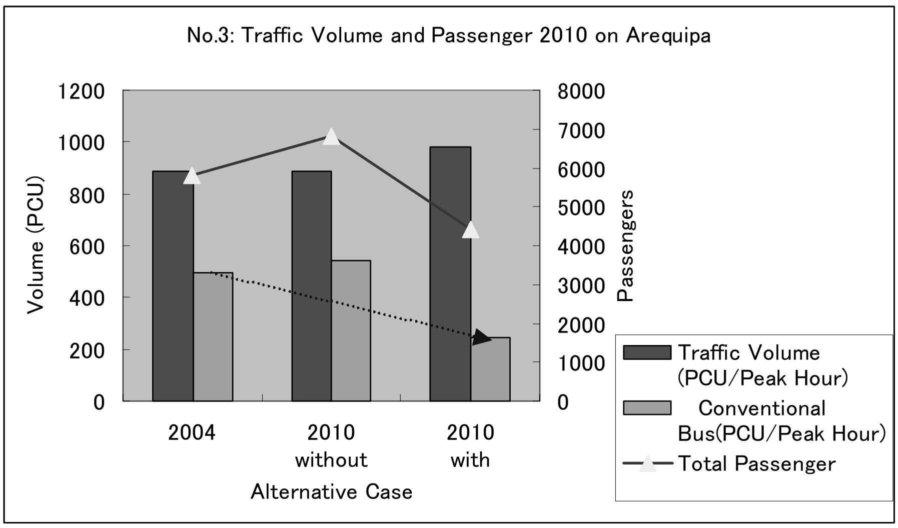


Figure 22.3-11 Traffic Volumes on Av. Arequipa

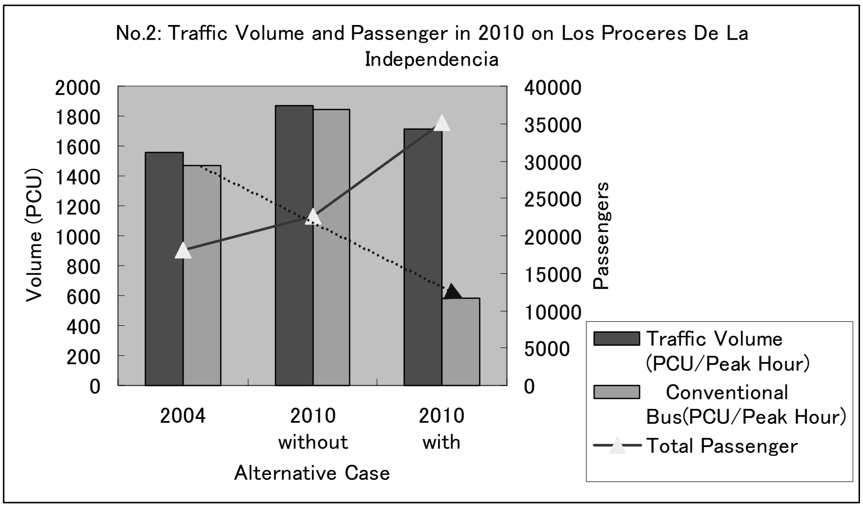


Figure 22.3-12 Traffic Volumes on Av. Los Próceres de La Independencia Parallel to the Mass Transit Lines

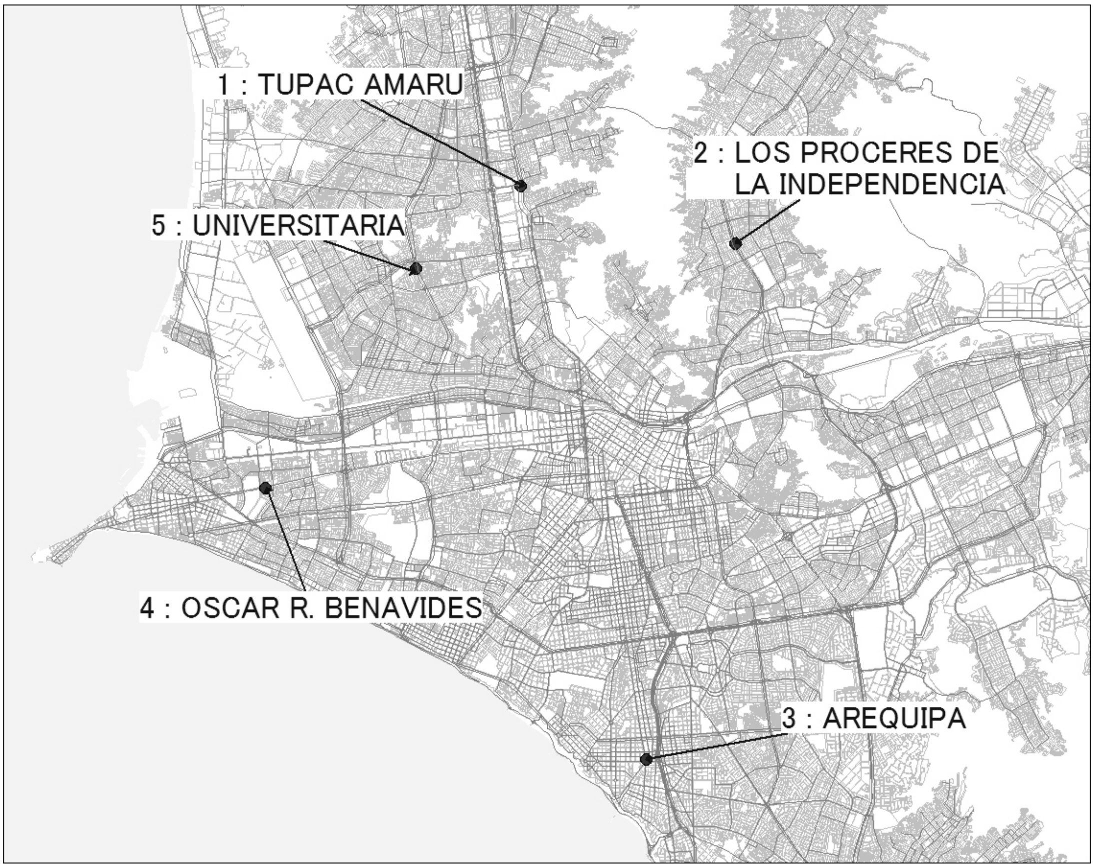


Figure 22.3-13 Location of the Roads

22.3.7. ECONOMIC BENEFIT FOR THE 2010 PROJECT

The cost benefit analysis of the short-term projects, which are composed of five (5) road, two (2) railway and thirteen (13) trunk bus projects, was carried out. The social benefit is measured in terms of savings of VOC and TTC by the projects in the same manner of that in 2025. The project cost is divided into two (2) categories: one is the purchase cost of the bus fleet and railway coach and the other is the cost of infrastructure and other items. In the railway coach, in order to reduce the initial investment cost, a used coach is introduced. The cost is estimated at 0.35 times the cost of a new one. The number of fleets and coaches is estimated in accordance with the number of operated frequencies by line, which is forecasted under the isolated fare system mentioned above.

Annual cash flow (benefit - cost) is analyzed during the Master Plan/project life period, as shown in Table 22.3-8. Under the discount rate of 12%, the benefit cost ratio (B/C) is 3.18 and the net present value (NPV) is US$ 2,688 million, which assures quite high economic returns for the Master Plan. The economic internal rate of return (EIRR) is also high at 34.7%.

Table 22.3-8 Cost- Benefit Analysis of Short-Term Projects in 2010

	Year	Construction Cost (1000US$)			Maintenance Cost (1000US$)			Total Cost	Benefit (1000US$)		
		Road	Railway	Trunk Bus	Road	Railway	Trunk Bus	(1000US$)	VOC	TTC	Total
	2004		0								
1	2005	14,256	40,306	94,015	0	0	0	148,577			
2	2006	56,430	40,306	94,015	0	0	0	190,751			
3	2007	74,744	80,612	69,967	0	0	18,803	244,126			
4	2008	63,560	42,007	69,967	2,376	24,184	18,803	220,896			
5	2009	40,648	42,007	58,119	2,376	24,184	18,803	186,136			
6	**2010**	40,648	56,010	58,119	2,376	24,184	18,803	200,139	153,151	588,290	741,442
7	2011	0	0	0	14,514	45,187	44,420	104,122	155,947	599,031	754,978
8	2012	0	0	0	14,514	45,187	44,420	104,122	158,794	609,967	768,762
9	2013	0	0	0	14,514	45,187	44,420	104,122	161,694	621,104	782,797
10	2014	0	0	0	14,514	45,187	44,420	104,122	164,646	632,443	797,089
11	**2015**	0	0	0	14,514	45,187	44,420	104,122	167,652	643,990	811,641
12	2016	0	0	0	14,514	45,187	44,420	104,122	170,712	655,747	826,459
13	2017	0	0	0	14,514	45,187	44,420	104,122	173,829	667,719	841,548
14	2018	0	0	0	14,514	45,187	44,420	104,122	177,003	679,910	856,912
15	2019	0	0	0	14,514	45,187	44,420	104,122	180,234	692,323	872,557
16	**2020**	0	0	0	14,514	45,187	44,420	104,122	183,525	704,962	888,487
17	2021	0	0	0	14,514	45,187	44,420	104,122	186,875	717,833	904,708
18	2022	0	0	0	14,514	45,187	44,420	104,122	190,287	730,938	921,226
19	2023	0	0	0	14,514	45,187	44,420	104,122	193,761	744,283	938,045
20	2024	0	0	0	14,514	45,187	44,420	104,122	197,299	757,872	955,170
21	**2025**	0	0	0	14,514	45,187	44,420	104,122	200,901	771,708	972,609
22	2026	0	0	0	14,514	45,187	44,420	104,122	204,569	785,797	990,366
23	2027	0	0	0	14,514	45,187	44,420	104,122	208,304	800,144	1,008,447
24	2028	0	0	0	14,514	45,187	44,420	104,122	212,107	814,752	1,026,859
25	2029	0	0	0	14,514	45,187	44,420	104,122	215,979	829,627	1,045,606
26	2030	0	0	0	14,514	45,187	44,420	104,122	219,922	844,773	1,064,696
27	2031	0	0	0	14,514	45,187	44,420	104,122	223,937	860,197	1,084,134
28	2032	0	0	0	14,514	45,187	44,420	104,122	228,026	875,901	1,103,927
29	2033	0	0	0	14,514	45,187	44,420	104,122	232,189	891,893	1,124,081
30	2034	0	0	0	14,514	45,187	44,420	104,122	236,428	908,176	1,144,604
31	2035	0	0	0	14,514	45,187	44,420	104,122	240,744	924,757	1,165,501
32	2036	0	0	0	14,514	45,187	44,420	104,122	245,140	941,640	1,186,780
33	2037	0	0	0	14,514	45,187	44,420	104,122	249,615	958,831	1,208,447
34	2038	0	0	0	14,514	45,187	44,420	104,122	254,172	976,337	1,230,509
35	2039	0	0	0	14,514	45,187	44,420	104,122	258,813	994,162	1,252,975
36	2040	0	0	0	14,514	45,187	44,420	104,122	263,538	1,012,312	1,275,850
Residual		0	0	0							
Total		290,284	301,248	444,202	442,554	1,428,166	1,407,818	4,314,272	6,309,792	24,237,418	30,547,211

EIRR = 34.7%
B/C = 3.18
NPV = 2,688

VOC: Vehicle Operation Cost

TTC: Travel Time Cost

22.4. HIGH PRIORITY PROJECTS FOR FURTHER STUDY IN 2010

22.4.1. PROCEDURE OF IDENTIFICATION OF HIGH PRIORITY PROJECTS

As mentioned above, the effectiveness of the development of the rapid mass transit on the traffic and transport conditions in 2010 was disclosed. Based on those analyses, the high priority projects are identified in consideration of the following viewpoints.

1) Peak hour travel demand on each project
2) Cost benefit analysis

A project with a higher travel demand is important. At the same time, a project with a higher cost-benefit ratio secures social benefits from the public transport service.

Figure 22.4-1 shows the relationship between the cost–benefit ratio and the total passengers per hour per dual-directions by projects, which is the total number of public transport users, not the flow rate on transport lines. The data of cost-benefit ratio used the cost benefit analysis elaborated in Chapter 19, Preparation of Implementation Program. TP-02 and 03 in Figure 22.4-1 are Line-1 (2) and Line-1 (3) of the railway projects and BP-01 to BP-13 are trunk busway projects.

As can be seen in Table 22.4-1, the projects are classified into two groups: one is a greater number of passengers and the other is a lower number of passengers. The former one refers to the railway projects. The later one refers to the trunk bus projects. The passengers on TPs-02 and 03 are approximately 172,000 /hour/dual-directions. The cost benefit ratios are approximately 3.2 to 3.5 As for the trunk busway projects, the passengers range between 4,000 and 100,000 /hour/dual-directions. The cost benefit ratios widely range from 0.4 to 9.7.

From among those projects, the projects with higher volumes of passengers and high B/C ratios are marked with a red circle for the trunk bus project and blue circle for the railway projects. Those projects are composed of railway Line-01 (North-south line), BP-01, 03 and 04 of trunk busway (east-west line), and BP-11, BP-12 and 13 of trunk busway. The COSAC-1 project (BP-02) is also included.

Table 22.4-1 Passenger Volumes and B/C Ratio by Projects

Project Name	Project No.	B/C Ratio	Passenger Volume /hour/Dual dir.
Av. Panamerican Norte	BP-12	9.7	63,591
Av. Panamerican Sur	BP-13	5.8	79,039
Carr. Central	BP-03	4.3	52,155
Av. Javier Prado	BP-11	4.1	67,170
COSAC Project	BP-02	4.0	103,600
Av. Venezuera	BP-04	2.4	21,563
Av. Grau	BP-01	1.8	52,155
Av. Brazil	BP-05	1.5	4,630
Av. Callao-Canta	BP-09	1.2	16,973
Universitaria South	BP-08	0.4	8,107
Railway Line-1 (2)	TP-02	3.5	171,998
Railway Line-1 (3)	TP-03	3.2	171,998

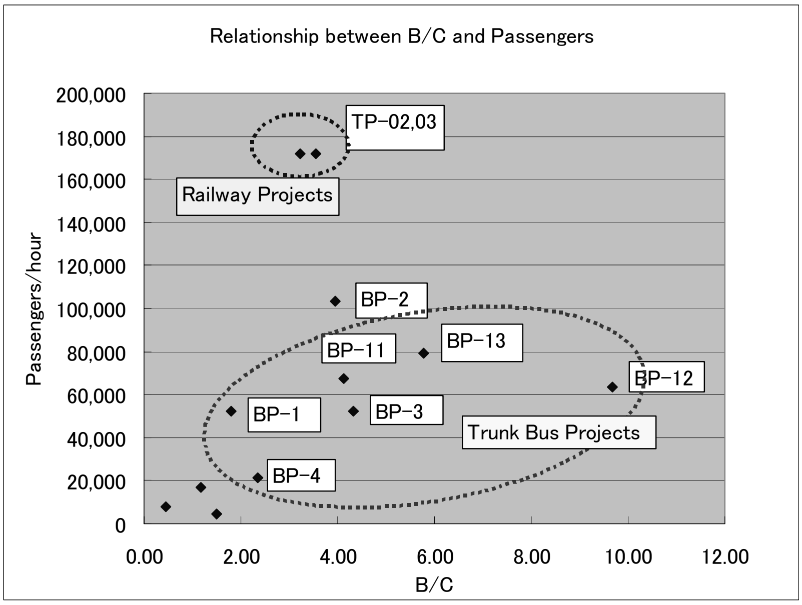


Figure 22.4-1 Relationship between Cost Benefit and Passenger Volumes by Projects

22.4.2. SELECTED HIGH PRIORITY PROJECTS

From those procedures, two (2) railway projects and four (4) trunk bus projects are identified as high priority projects for further studies as shown below.

1) Railway Projects
   a) TP-02: Railway Line-1 (2)
   b) TP-03: Railway Line-1 (3)
2) Trunk Bus Projects
   a) BP-03 Carretera Central
   b) BP-04 Av. Venezuela
   c) BP-12 Av. Panamericana Norte
   d) BP-13Av. Panamericana Sur

   Since BP-01: Av. Grau and BP-02: COSAC-1 Projects are on-going projects, this project is excluded from the high priority project. COSAC-1 (High Capacity Segregated Corridor) is a rapid bus transport project operated under a trunk-feeder bus system financed by the World Bank and Inter-American Development Bank (IBD). The Project Appraisal Report of the COSAC-1 project was submitted to the World Bank and IDB in November 2003. The execution of the project will commence between July and December 2004 and the operation will commence in March 2006.

BP-11, Av. Javier Prado, is also excluded from the high priority projects. Av Javier Prado has a road improvement plan. It is necessary to carry out further studies for the construction of the trunk busway on the median of the road when considering this improvement plan. This study must be carried out during the progress of the improvement plan.

Table 22.4-2 shows the project outline for the investment cost and operation frequency in the peak hour. The investment cost is divided into two (2) categories: infrastructure cost and bus fleet and railway coach cost, whose costs are estimated based on the service frequency in the peak hour. In the railway, a train of 6 coaches is operated with a minimum headway of 2.5 minutes. In the trunk bus system, an articulated bus is operated with a minimum headway of 0.5 minutes (30 sec.) on Av Panamericana Norte.

The total investment costs of the projects are approximately US$592 million, of which US$377 million are for the railway projects and US$215 million are for the trunk busway projects, excluding bus terminal costs.

Table 22.4-2 Project Outline for Investment Cost and Passengers

Project No.	Project Name	Line No.	Project Size (km)	Project Cost (1000US$) Infrastruction	Project Cost (1000US$) Fleet and Coach	Project Cost (1000US$) Total	Headway (min)	Total Passengers /hour/direction
TP-02	Line-1 (2)	BT7011	11.7	132,439	138,182	270,621	2.5	77,530
TP-03	Line-1 (3)	BT7012	13.0	105,939		105,939	2.3	94,468
BP-03	Carr. Central	BC2012	8.4	16,260	11,250	27,510	0.8	22,217
BP-04	Av. Venezuera	BC2031	9.1	17,590	10,787	28,377	1.9	9,870
		BC2032					1.5	11,693
BP-12	Av. Panamerican Norte	BC2061	23.9	50,650	27,132	77,782	0.5	38,732
		BC2062					0.9	24,859
BP-13	Av. Panamerican Sur	BC2051	25.6	59,720	22,059	81,779	1.0	35,209
		BC2052					0.7	43,830
Total			91.6	382,598	209,410	592,008	-	-

22.5. DESCRIPTION OF HIGH PRIORITY PROJECT

22.5.1. RAILWAY PROJECTS

In the Urban Transport Master Plan with target year 2025, four (4) railway projects including railway Line-1, Line-2, Line-3, and Line-4 projects are recommended for the Long Term Plan. Additionally, in Chapter 19, the railway Line-1 project was selected as the project of the Short Term Action Plan with target year 2010, based on the technical, environmental and economic evaluation. The outline and necessity of the railway project, and the effectiveness of the railway Line-1 project, are described in this section.

(1) Location of the Railway Route of Line-1

The railway Line-1 project can be classified into three (3) sections, considering the study progress of the project. The general conditions of the three (3) sections are presented in Table 22.5-1.

Table 22.5-1 Conditions of Each Section of the Line-1 Project

Items	Line -1 Project (Total length is 33.9 km) Section-1	Section -2	Section-3
Length (km)	9.2	11.7	13.0
Engineering Stage	Completed	Completion of Feasibility Study	Preparation of Master Plan Study
Construction Stage	Completed	Expected in 2006	---------------------------
Operation Stage	Operated part time	-----------------------------	---------------------------
Present Stage	Operated part time	Preparation of concession conditions	Preparation of Master Plan Study
Implementation Authority	AATE	AATE	---------------------------
Type of structure	At-Grade Viaduct	Viaduct	At-Grade Viaduct

As shown in Figure 22.5-1, the railway route of Section-1 of Line-1 is located on the existing Av. Pachacutec and Av. De Los Héroes. The railway structure of Section-1 is already constructed. The route of Section-2 is located on the existing Av. Santiago de Surco and Av. Aviación, and the foundation structure on some parts of Section-2 are already constructed. The route of Section-3 is located on the existing Av. Grau and Av. Independencia in San Juan de Lurigancho crossing the existing freight railway line and Ríimac River.

Figure 22.5-1 Location Map of the Railway Route of Line-1

(2) Operation System

As mentioned in Chapter 15.7.3 of this report, the railway operation system is formed by the railway and bus transport network. The bus routes should be linked at the railway stations and terminals. Particularly, the railway passengers living in influenced areas of the railway should be carried by the feeder bus system, using the integrated system between the railway and feeder bus system at the stations and terminals.

(3) Railway Passenger Demand in 2010 and 2025 on the Line-1 Project

The number of passenger boarding and alighting at each station in 2010 and 2025 are shown in Figure 22.5-2 and Figure 22.5-3. The railway passenger demand during peak hours in 2010 and 2025, by direction and by segment, of the Line-1 project is summarized in Table 22.5-2 based on the Figure 22.5-2 and Figure 22.5-3. The detailed methodology and results of the passenger demand are described in Chapter 21 of this report.

From Table 22.5-2, the following passenger characteristics are pointed out.

a) The percentage of inbound (S to N direction) and outbound (N to S direction) passengers in 2010 on Av. Aviación is estimated at approximately 58% and 42% respectively.
b) The percentage of inbound (N to S direction) and outbound (N to S direction) passengers in 2010 in the San Juan de Lurigancho area is estimated at approximately 62% and 38% respectively.
c) The maximum number of passenger during peak hour in 2010 is estimated at 39,000 passengers near the Center of Lima.
d) The number of passenger during peak hour in 2010 from San Juan de Lurigancho to the Center of Lima is estimated at 36,000 persons.
e) The maximum number of passenger during peak hour in 2010 (36,000 persons) from San Juan de Lurigancho to the Center of Lima Centro obviously exceeds the transport capacity of the trunk bus transport system(25,000 persons). Therefore, the railway system in this area should be realized as soon as possible.
f) The maximum number of passengers during peak hour in 2010 (39,000 persons) from Villa El Salvador to the Center of Lima obviously exceeds the transport capacity of the trunk bus transport system (25,000 persons). Therefore, the railway system in this area should be realized as soon as possible.

Table 22.5-2 Passenger Demand on Line-1 Project

Railway Route Sections	Passenger Demand During Peak Hour in 2010		Passenger Demand During Peak Hour in 2025	
	Inbound (S—N) (persons/hour)	Outbound (N-S) (persons/hour)	Inbound (S-N) (persons/hour)	Outbound (N-S) (persons/hour)
Av. De Los Héroes	20,000-25,000	14,000-21,000	21,000-32,000	21,000-25,000
Av. Santiago de Surco	29,000-30,000	22,000-29,000	39,000-40,000	32,000-41,000
Av. Aviación in San Borja	32,000-34,000	31,000-37,000	44,000-50,000	45,000-52,000
Av. Aviación in La Victoria	32,000-34,000	37,000-39,000	47,000-55,000	53,000-61,000
Av. Aviación and Av. Grau	17,000-28,000	37,000-39,000	45,000-46,000	53,000-54,000
Av. Grau ----Rímac River	21,000-22,000	34,000-37,000	32,000-33,000	55,000-57,000
Rímac River-----Av. Lurigancho	20,000-21,000	35,000-36,000	29,000-30,000	49,000-54,000
Av. Lurigancho----Av. Los Postes	17,000-18,000	30,000-35,000	21,000-24,000	38,000-47,000
Av. Los Postes-----Terminal	14,000-15,000	23,000-29,000	16,000-18,000	25,000-34,000

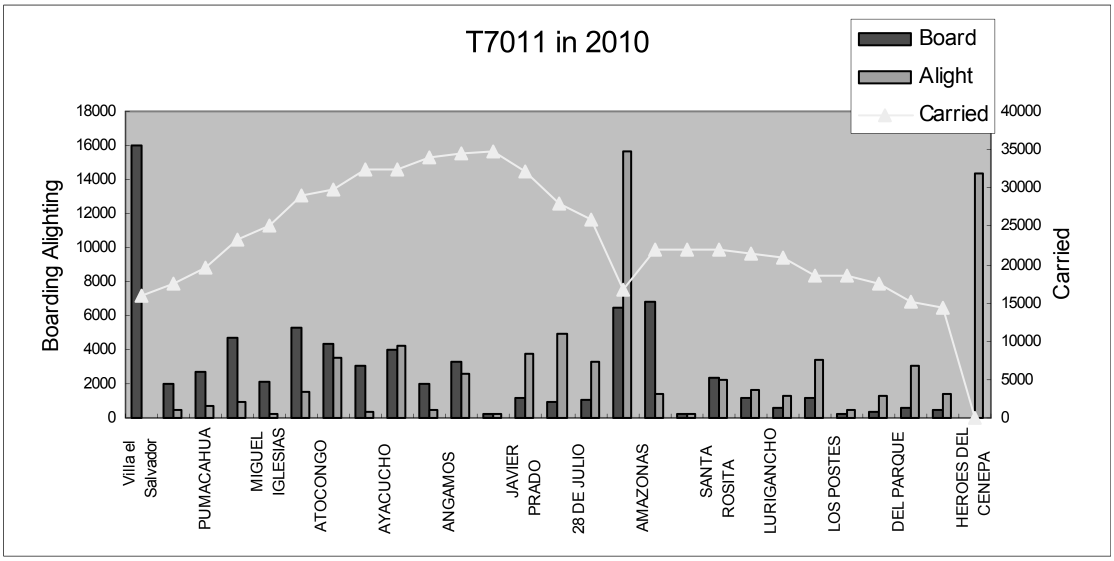


Figure 22.5-2 Passenger Demand on the Line-1 Project in 2010

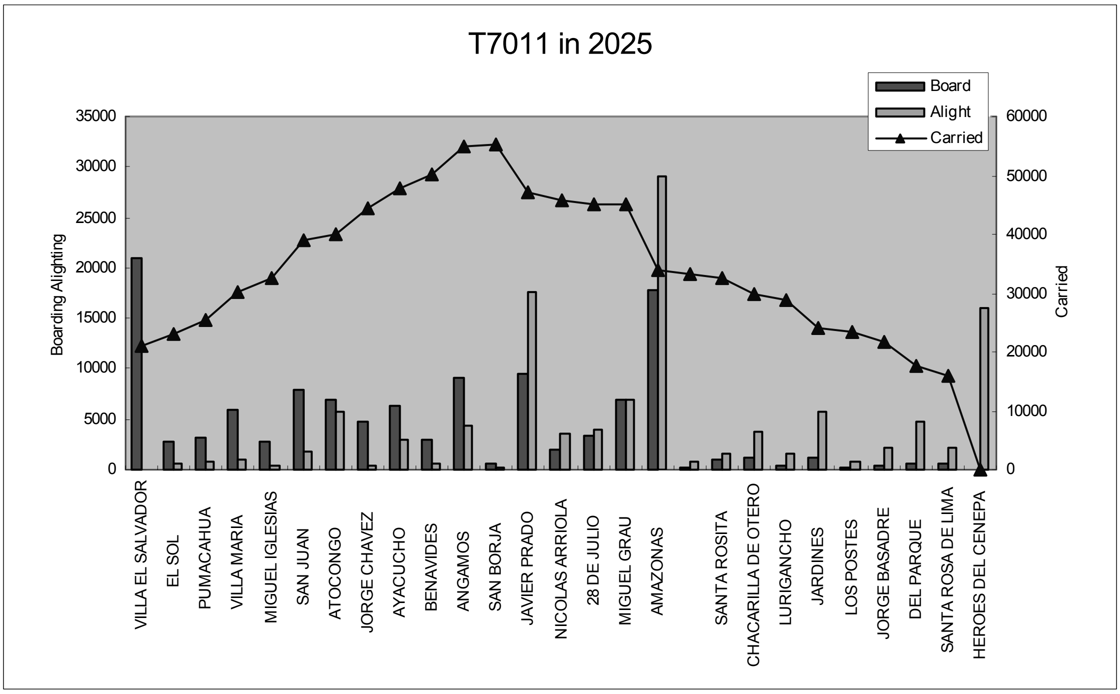


Figure 22.5-3 Passenger Demand on the Line-1 Project in 2025

(4) Railway Transport Capacity

The railway transport capacity is estimated in the previous Chapter 15.7.3 of this report. The results of the estimation are summarized in Table 22.5-3.

Table 22.5-3 Railway Transport Capacity based on Different Conditions

Items	Number of Passengers per Coach (Persons) (A)	Number of Coaches per Train (Units) (B)	Number of Passengers Per Train (Persons) (A)*(B)=(C)	Operation Headway (Minutes) (D)	Operation Frequency Per Hour (Times) 60/(D)=(E)	Capacity per Hour per Direction Per Lane (Persons) (C)*(E)=(F)
Railway Transport	250	10	2,500	2.5	24	60,000
				4	15	37,500
	250	8	2,000	2.5	24	48,000
				4	15	30,000
	250	6	1,500	2.5	24	36,000
				4	15	22,500

(5) Operation Frequency in 2010

The railway operation frequency of the Line-1 project in 2010 is examined in oder to compare it with the number of estimated passengers and the transport capacity. The results of the peak hour operation frequency are presented in Table 22.5-4.

Table 22.5-4 Peak Hour Operation Frequency in 2010 at Railway Line-1.

Items	Unit	Quantity
Max. No. of Passenger	Persons	39,000
No. of Coaches/Train	**Vol.**	**6**
Operation Headway	**Minutes**	**2.5**
Capacity/Hour	Persons	36,000
Frequency/Hour	Times	24

(6) Number of Coaches Required

Based on the peak hour operation frequency mentioned previously, the number of coaches required in 2010 is calculated considering the following conditions.

a) Operation frequency per hour (Of)= 24 Times
b) Number of coach per train (Nc)= 6 coaches
c) Operation cycle time per hour (Oc)=(route length/ operation speed)+loss time of terminal=1.61 times
d) Contingency coaches (Cc)= 10% =1.1 Times
e) No. of coaches required=Of * Nc * Oc * Cc

As a result of the calculation, the number of coaches required in 2010 is estimated at 270 coaches.

(7) Railway Infrastructure Facilities

1) Railway Road Facility

As mentioned previously, the railway route of Line-1 is located on the central area of the existing roads, and the structure types of the railway on the road sections is examined based on the development conditions, road facility conditions, and environmental conditions along the existing roads. As a result of the examination, the types of structures are summarized in Table 22.5-5.

Table 22.5-5 Type of Structure by Section

Railway Sections	Type of Structure	Location Site	Remarks
Av. De Los Héroes	Viaduct	Center of Existing Road	All Structures are Constructed
Av. Santiago de Surco	Viaduct	Center of Existing Road	Foundations are Constructed
Av. Aviación in San Borja	Viaduct	Center of Existing Road	Foundations are Constructed
Av. Aviación in La Victoria	Viaduct	Center of Existing Road	New Construction
Av. Aviación and Av. Grau	Viaduct	Center of Existing Road	New Construction
Av. Grau ----Rímac River	On-Ground	Center of Existing Road	New Construction
Rímac River-----Av. Lurigancho	Viaduct	Beside Rímac River	New Construction
Av. Lurigancho----Av. Los Postes	On-Ground	Center of Existing Road	New Construction
Av. Los Postes-----Terminal	On-Ground	Center of Existing Road	New Construction

2) Railway Station Facility

The location of the railway stations is examined to be discussed with the engineers of AATE, in order to conduct the full reconnaissance survey and the conduct economic and social condition surveys along the railway route. When the location of the stations is selected, the following matters should be considered.

a) Stations should be located at the crossing points of the major trunk roads.
b) Stations should be located in the high development areas.
c) Stations should be located at intervals of approximately 1.0 km to 1.5 km.

As a result of the examination, the locations of the railway stations are shown in Figure 22.5-1. At present, five (5) railway stations in Line-1 are already constructed and partially operated. These stations can be used on the railway Line-1 project recommended by the Short-Term Action Plan.

3) Railway Depot and Related Facilities

At present, the railway depot and operation center are constructed and partially operated. The railway Line-1 project can use these facilities. However, when section-3 of railway Line-1 is constructed, the construction of a new depot is required at the northern part of the San Juan de Lurigancho area due to a shortage of the space in the existing depot.

(8) Project Cost Estimate

Based on the past railway construction projects, the project cost of railway Line-1 is estimated as shown in Table 22.5-6. The project cost includes the Construction cost (A), Engineering cost (A)*10%, Contingency cost (A)*15%, and Administration cost (A)*10%. For reduction of the project costs, the used coaches should be introduced during the Short-Term Action Plan. The cost of a used coach is estimated at approximately 35% of the cost of a new coach.

Table 22.5-6 Project Cost of Line-1 (Section 2 and 3)

Items	Unit	Quantities	Unit Cost	Project Cost (thousand US$)
Structure (section 2&3)	Vol.	1	81,400	81,400
		1	39,800	39,800
E/M(Electric & Track) (section 2&3)	Vol.	1	51,100	51,100
		1	65,000	65,000
Depot (section 2&3)	No.	0	0	0
		1	1,200	1,200
Rolling Stock (section 2&3)	No.	270	512*	138,000
Total				376,500

* : Coach cost (Used coach) is adopted at 35% of the cost of a new coach (US$ 1.463 million).

(9) Effectiveness of the Railway Line-1 Project

The detailed effectiveness of Long and Short-Term Plans are examined in the previous Chapter 21 and 22 of this report, based on the comparison between the With Project case and Without Project case.

In this section, the effectiveness of the mass transit project is summarized based on the results of the effectiveness study of the Long and Short-Term Plans. The major effectiveness on the existing roads, which are located near the mass transit project, are summarized as shown in Figure 22.5-4 and Figure 22.5-5 which show total traffic volume, the conventional bus volume and total passengers of public transport on major roads parallel to the mass transit lines. As can be seen, the conventional buses on roads parallel to the mass transit lines considerably decrease in number due to the diversion to the mass transit system. However, in order to increase the number of future private vehicles, the total traffic volume on the roads slightly increases.

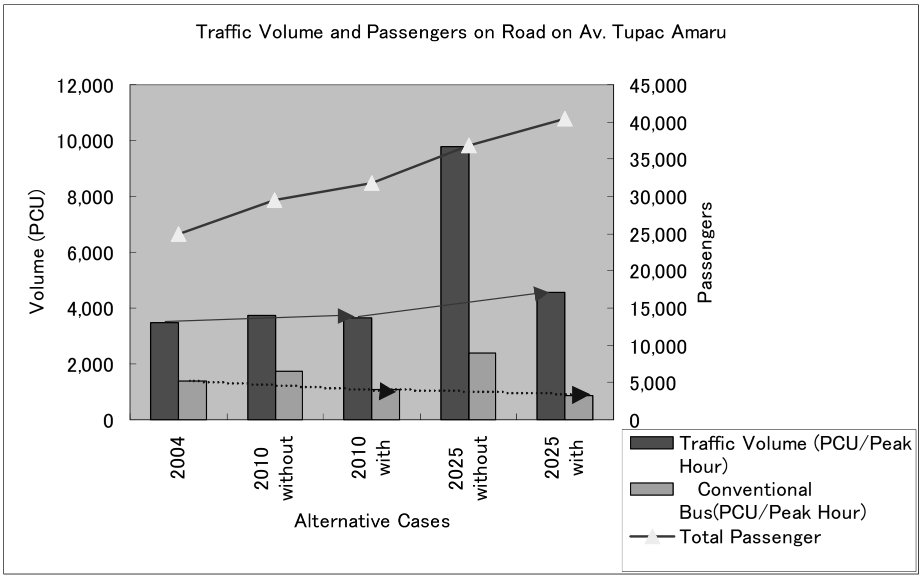


Figure 22.5-4 Traffic Volumes on Av. Tupac Amaru Parallel to the Mass Transit Lines

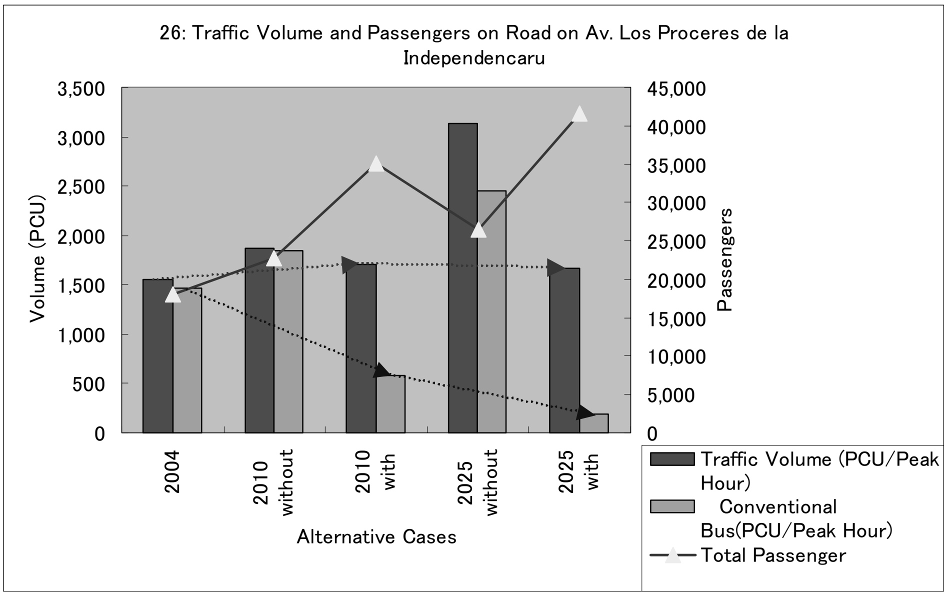


Figure 22.5-5 Traffic Volumes on Av. Los Próceres de La Independencia Parallel to the Mass Transit Lines

(10) Advantage of the Railway Project in the Lima and Callao Metropolitan Area

The cross section of the existing trunk roads is developed by 6 to 8 lanes dual carriageways with about 10 meters of central reservation and about 5 meters of sidewalks on both sides. In addition, approximately 9.2 km of railway infrastructure has already been constructed in the Villa el Salvador and San Juan de Miraflores areas.

Considering the characteristics of existing transport facilities in the Lima and Callao Metropolitan Area, the following advantages for the introduction of railway projects are highlighted. To ensure the various advantages of the implementation of the railway project, the railway Line-1 project should be realized as soon as possible.

1) Railway structures of the Line-1 project can be developed using the central reservation space of the existing trunk roads. Therefore, the following advantages are ensured.
   a) Construction cost and project cost can be decreased.
   b) Railway structures can be constructed without additional land acquisition.
   c) Railway structures can be constructed without a large number of re-settlements.
2) Railway structures of the Line-1 project can be developed using approximately 9.2 km of the existing railway structure and related facilities such as the railway depot and operation center. Therefore, the following advantages are ensured.
   a) Railway Line-1 can be contributed effectively to use the existing facilities.
   b) Construction cost and project cost can be decreased.
3) The number of public transport passengers on the trunk roads obviously exceeds the transport capacity of bus transport. The peak hour passenger demands per direction in 2010 and 2025 of railway Line-1 are estimated at 39,000 persons and 61,000 persons. The railway projects can maintain the large number of public transport passengers.
4) Railway projects can contribute to the following environmental aspects based on the large transport capacity of the railway.
   a) Railway project can contribute to decrease air pollution since many passengers

are transferred from bus transport to railway transport.

b) Railway projects can contribute to mitigate traffic congestion.

5) At present, AATE intends to promote the extension of the existing railway project by concession system, and the conditions of the concession system will be decided soon.

22.5.2. TRUNK BUSWAY PROJECTS

The outline of the four (4) trunk busway projects included as high priority projects is shown below.

(1) Location of the Trunk Busway

Figure 22.5-6 shows the location map of the trunk busways selected as high priority projects, which are composed of BP-01: Av. Grau, BP-03: Carretera Central, BP-04: Av. Venezuela, BP-12: Av. Panamericana Norte, and BP-13: Av. Panamericana Sur. As can be seen, the configuration of the busways is formed in the shape of a cross, in an east-west direction and a north-south direction.

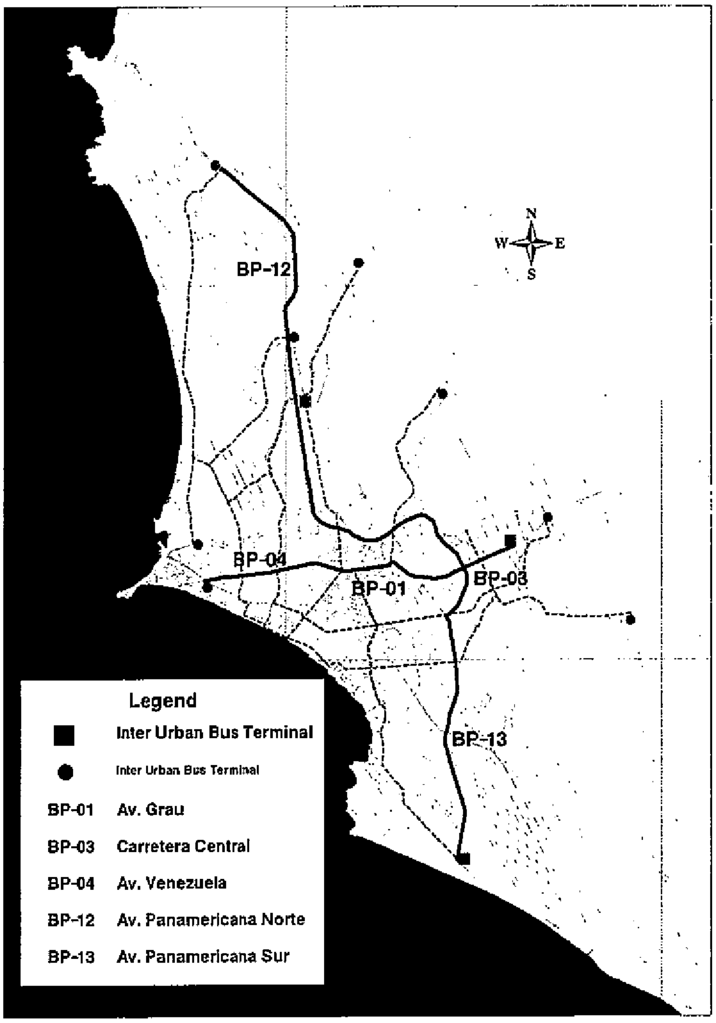


Figure 22.5-6 Location Map of the Trunk Busways Selected as High Priority Projects

(2) Operation System

The trunk bus system is composed of trunk bus, feeder bus and conventional bus services. The trunk bus service is operated with higher operation speed on the busway, which may be partially segregated or fully segregated from other traffic by curbs or fences to secure operation conditions such as speed, punctuality and safety. The trunk bus system has a higher volume of bus passengers.

The function of feeder buses is to supplement the service of the trunk bus. The feeder buses serve within some areas where trunk buses do not operate. The feeder bus system operates in an area around a trunk bus terminal to carry passengers to and from the terminal. Its service area is limited to a relatively small area in the suburbs, with a relatively short route length and a smaller number of passengers per bus.

The conventional bus system operates the bus lines other than the trunk bus and the feeder bus lines. The present operation system, including bus lines, service frequency, bus companies and so forth, is retained without any change. The conventional bus service is operated on the same system (route) as that at the present, but bus routes diverted to trunk busways will be abolished by degree of competition with the trunk bus route. The conventional buses will operate on roads outside of the segregated busway.

(3) Trunk Busway Capacity

The trunk bus capacity is estimated in the previous Chapter 14.6.4. The results of the estimation are summarized in Table 22.5-7. The capacity of the articulated bus is set at 200 passengers in the peak hour.

Table 22.5-7 Service Frequency and Transport Capacity of the Trunk Bus System

Service Frequency (Headway)	No. of Buses operated (units/hour) (A)	Capacity per Articulated Bus (B)	Transport Capacity per hour (persons/direction/line) (A x B)	Remarks
20 seconds	180	200	36,000	Difficult in operation
30 seconds	120	200	24,000	-
45 seconds	80	200	16,000	-
60 seconds	60	200	12,000	-
90 seconds	40	200	8,000	-
120 seconds	30	200	6,000	-

(4) Operation Frequency in 2010

Table 22.5-8 shows the number of service frequencies and passengers by transport line in the peak hour. The line No. in Table 22.5-8 shows lines by up and down buses on the line operated on the trunk busway. The heaviest volume of passengers are found on the project No. BP-13. The total passengers by line are approximately 35,000 and 44,000 passengers/hour, respectively. The frequencies are 60 and 90 times/hour, which are equivalent to a minimum headway of 60 and 40 seconds in each direction.

The lighter volume of passengers are found on project No. BP-04: Av. Venezuela. There are approximately 10,000 passengers/hour in each direction. The minimum headway is 90 seconds.

Table 22.5-8 Number of Service Frequencies and Passengers by Line in the Peak Hour

Project		Line No.	Line Length (km)	Frequency (Times/hour)	Headway (min)	Total Passengers /hour
No.	Name					
BP-01	Av. Grau	BC2011	14.32	106	0.57	29938
BP-03	Carretera Central	BC2012	14.34	75	0.8	22217
BP-04	Av. Venezuela	BC2031	15.28	32	1.88	9870
		BC2032	15.27	40	1.5	11693
BP-12	Av. Panamericana Norte	BC2061	45.06	111	0.54	38732
		BC2062	44.92	70	0.86	24859
BP-13	Av. Panamericana Sur	BC2051	44.47	59	1.02	35209
		BC2052	44.44	88	0.68	43830
Total			238.1	581		

(5) Number of Articulated Bus Fleets

The number of operated bus fleets is estimated in accordance with the service frequency, operation cycle time per hour, and contingency fleets. In this case, the number of required bus fleets is roughly estimated at 580 bus fleets.

(6) Trunk Busway Infrastructure Facilities

The facility of the trunk bus system is composed of the trunk busway, bus stop and integrated bus terminal. The trunk busway facility selected as a high priority project is segregated by some concrete structure from the through traffic lane in order to ensure the regular trunk bus service according to schedule and the traffic safety. The busway is closed to pedestrians, bicycles, taxis and other motor vehicles throughout the day. The selected roads that introduce the trunk busway will have two to three one-way lanes on both sides of the busway for regular motorized traffic.

In Chapter 14, the busways on Av. Panamericana Sur and Norte are planned next to the right-side sidewalk. The other busways are located on the median side of the existing roadway. However, it is necessary to carry out further studies for the location of the busways.

The main physical determinations of the average commercial bus speed appear to be the bus stops and intersection spacing. Bus stop capacity is an important determinant of the overall bus system performance. Bus stop spacing also influences performance. The longer the stop spacing is, the higher the commercial speed is.

Since there is a close relationship between bus stop facilities, such as spacing and capacity, and the type of trunk bus introduced, size of body, location of doors and height of floor etc., it is necessary to carry out further studies.

(7) Project Cost

In previous section, two (2) railway projects, thirteen (13) trunk bus projects including three (3) bus terminal projects, ten (10) road projects, and eight (8) traffic management projects are recommended as the Short Term Plan in 2010.

The project cost of the Short Term Plan is estimated to adopt the same calculation conditions and method of the Master Plan in 2025. Therefore, basically, the project cost of each project recommended by the Short Term Plan in 2010 is same as the project cost of each project recommended by the Master Plan in 2025. The detailed project cost of each project recommended by the Master Plan in 2025 was estimated and presented on each Sector Plan study in Chapter 12, 13, 14, and 15 in this report.

The infrastructure cost of the trunk bus projects and railway projects in the Short Term Plan in 2010 is same as the project cost of the Master Plan in 2025, however, the articulated bus fleets and wagons cost for railway project purchase are estimated at the deferent between the Short Term Plan in 2010 and the Master Plan in 2025. Because, the numbers of articulated bus fleets and wagons for railway projects are estimated based on the passenger demand in 2010, and the Master Plan was estimated based on the passenger demand in 2025 respectively.

The results of project cost by infrastructure and bus fleets and wagon for railway projects are presented in Table 22.5-9 and each project cost is presented in Table 22.6-1.

Table 22.5-9 Project Cost of Short Term in 2010

Project	Project Cost (1,000 US$)		
	Infra.	Fleets	Total
Railway Projects	238,378	138,182	375,560
Trunk Bus Projects	398,700	156,553	555,253
Road Projects	289,855	----------	289,855
Traffic Management Projects	73,000	----------	73,000
Total	999,933	294,734	1,294,667

(8) Advantage of the Trunk Bus Project

Buses are one of the most space-efficient and cost-efficient means of transporting large numbers of people. In the Lima metropolitan area, where road traffic volume is high in relation to road capacity, buses suffer from the congestion and delay caused by the bus itself and other road users, and priority measures are needed to release buses from congestion of traffic and bus transport itself. The trunk bus system is recommended as a high priority project taking into consideration the importance of strengthening the public transport system in the study area. The followings advantages have been summarized with regards to the trunk bus project.

1) Trunk busway structures can be developed using the central reservation space of the existing trunk roads. Therefore, the following advantages are ensured.
   a) Construction cost and project cost can be decreased.
   b) Busway structures can be constructed without additional land acquisition.
   c) Busway structures can be constructed without a large number of re-settlements.
2) The public transport passenger volumes on the trunk roads will obviously exceed the transport capacity in the existing bus transport system. The peak hour passenger demands per direction in 2010 on BP-13: Av. Panamericana Sur is estimated at 44,000 persons/hour/direction. It is possible to transfer the large number of public transport passengers in the trunk busway projects.
3) The trunk bus project can contribute in the following environmental aspects.
   a) The project can contribute to decrease the air pollution as a result of the reduction of the bus fleets.
   b) The project can contribute to alleviate the traffic congestion as a result of the reduction of the bus fleets.

22.6. SUMMARY OF THE SHORT-TERM AND HIGH PRIORITY PROJECT COSTS

Table 22.6-1 shows the summary of the short-term and high priority project costs. The total project cost of the short-term project is approximately US$1,295 million, of which US$377 million are for the railway project, US$555 million are for the trunk bus project, US$290 million are for road project, and US$73 million are for the traffic management project.

The high priority project cost is approximately US$674 million. The railway project cost in the high priority project is approximately US$377 million, which is the same as that in the short-term project. The cost of a railway coach, which is estimated at about 35% of the cost of a new coach, is approximately US$138 million, which is equivalent to 37% of the total. The trunk bus project cost is approximately US$224 million, of which US$215 million are for busways and US$9 million are for bus terminals. The ratio of the bus fleet cost to the busway is approximately 33%. The bus cost is estimated as an articulated bus.

The traffic management project cost is approximately US$73 million in the short-term and high priority projects.

Table 22.6-1 Summary of the Short-Term and High Priority Project Costs

Project Name	Size	Project Cost in 2010 (1000US$)			High Priority Project Cost (1000US$)
	km	Infrastructure	Bus & Coach	Total	
Railway Project					
TP-02 Line-1 (2)	11.7	132,439	69,091	201,530	201,530
TP-03 Line -1 (3)	13	105,939	69,091	175,030	175,030
Sub-Total	24.7	238,378	138,182	376,560	376,560
Trunk Bus Project					
BP-01 Av. Grau	2.3	27,100	15,789	42,889	Under Construction
BP-02 COSAC Project	29	155,430	33,718	189,148	Under Construction
BP-03 Carretera Central	8.36	16,260	11,250	27,510	27,510
BP-04 Av. Venezuela	9.05	17,590	10,787	28,377	28,377
BP-05 Av. Brasil	4.84	550	2,550	3,100	
BP-08 Universitaria Sur	12.66	32,870	4,798	37,668	
BP-09 Av. Callao-Canta	9.13	18,130	7,348	25,478	
BP-11 Av. Javier Prado	21.07	11,400	21,120	32,520	
BP-12 Av. Panamericana Norte	23.9	50,650	27,132	77,782	77,782
BP-13 Av. Panamericana Sur	25.6	59,720	22,059	81,779	81,779
BP-18 Terminal A	I unit	3,000		3,000	3,000
BP-19 Terminal-B	1 unit	3,000		3,000	3,000
BP-20 Terminal-C	1 unit	3,000		3,000	3,000
Sub-Total		398,700	156,553	555,253	224,448
Road Project					
RP-13 República Sur	5	62,100		62,100	
RP-15 Elmer Faucett	5.6	59,400		59,400	Under Construction
RP-18 Av. Universitaria	2.7	9,320		9,320	
RP-19 Av. Independencia	3.3	22,950		22,950	
RP-25 Intersection Package-1	19 No.	76,950		76,950	
RP-28 Widening Urban Area	161	17,310		17,310	
RP-30 Roads in Housing Area	202.8	17,745		17,745	
RP-31 Expressway Rehabilitation	100	13,675		13,675	
RP-32 Arterial Rehbilitation	567	5,740		5,740	
RP-33 Collector Rehabilitation	691	4,665		4,665	
Sub-Total		289,855		289,855	
Traffic Management Project					
MP-01 Traffic Signal Control	1 unit	38,640		38,640	38,640
MP-02 Intersection Improvement	1 unit	650		650	650
MP-03 TDM Introduction	1 unit	5,540		5,540	5,540
MP-04 Traffic Safety	1 unit	650		650	650
Mp-05 Parking Control	1 unit	2,400		2,400	2,400
MP-06 Safety Education	1 unit	1,620		1,620	1,620
MP-07 Accident Monitoring	1 unit	2,700		2,700	2,700
MP-08 Vehicle Inspection	1 unit	20,800		20,800	20,800
Sub-Total		73,000		73,000	73,000
Total Project Cost		999,933	294,734	1,294,667	674,008