CHAPTER 15

Railway Transport Sector Plan

15. RAILWAY TRANSPORT SECTOR PLAN

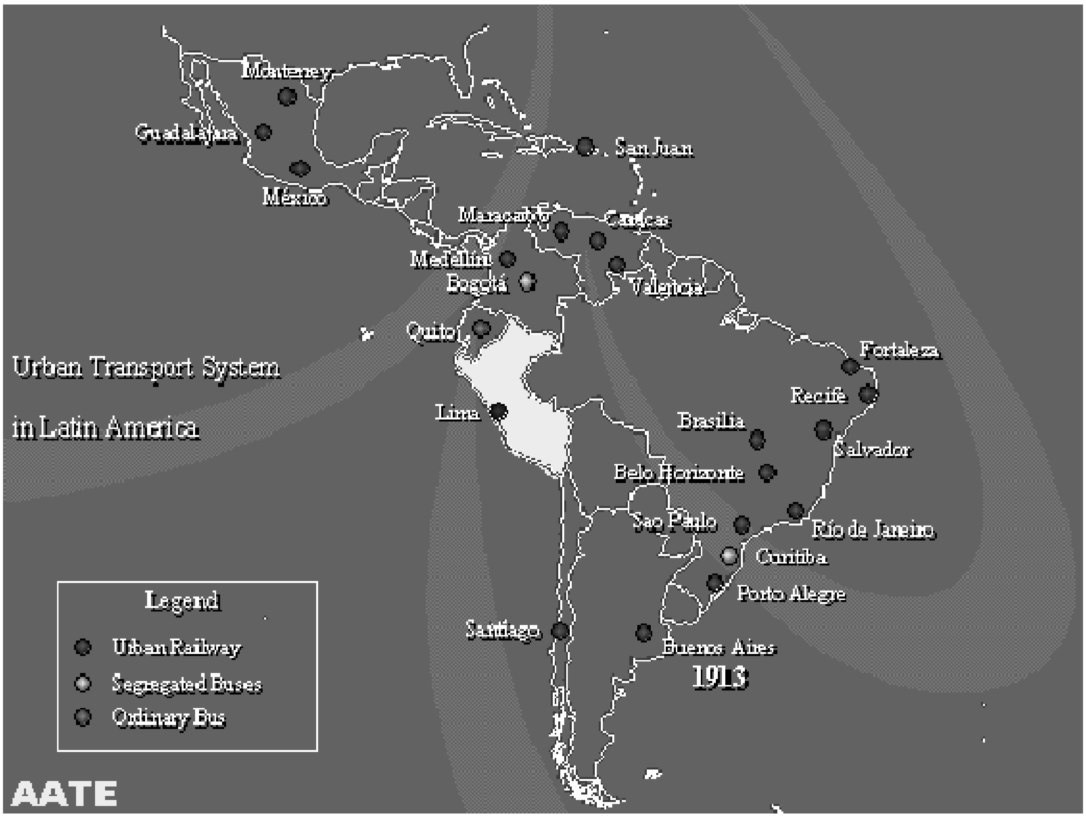
15.1. GENERAL

This section describes the present situation and future development program of the urban railway in Lima and Callao. The Urban Railway Authority (AATE), who took responsibility as the Autonomous Authority for the railway development project of the Electric Mass Transport System of the Municipality of Lima, has the objective of improving the growing traffic problems in the metropolitan area.

15.2. ENVIRONMENTAL CONSIDERATION

15.2.1. URBAN RAILWAY CONDITIONS IN LATIN AMERICA

Most of the Latin American capitals are located on the coasts of the Pacific and Atlantic Ocean, and most countries own their urban railway system as shown in Figure 15.2-1. Figure 15.2-2 shows the present urban railway length in the metropolitan areas in Latin America.



Source: AATE

Figure 15.2-1 Urban Transport System in Latin America

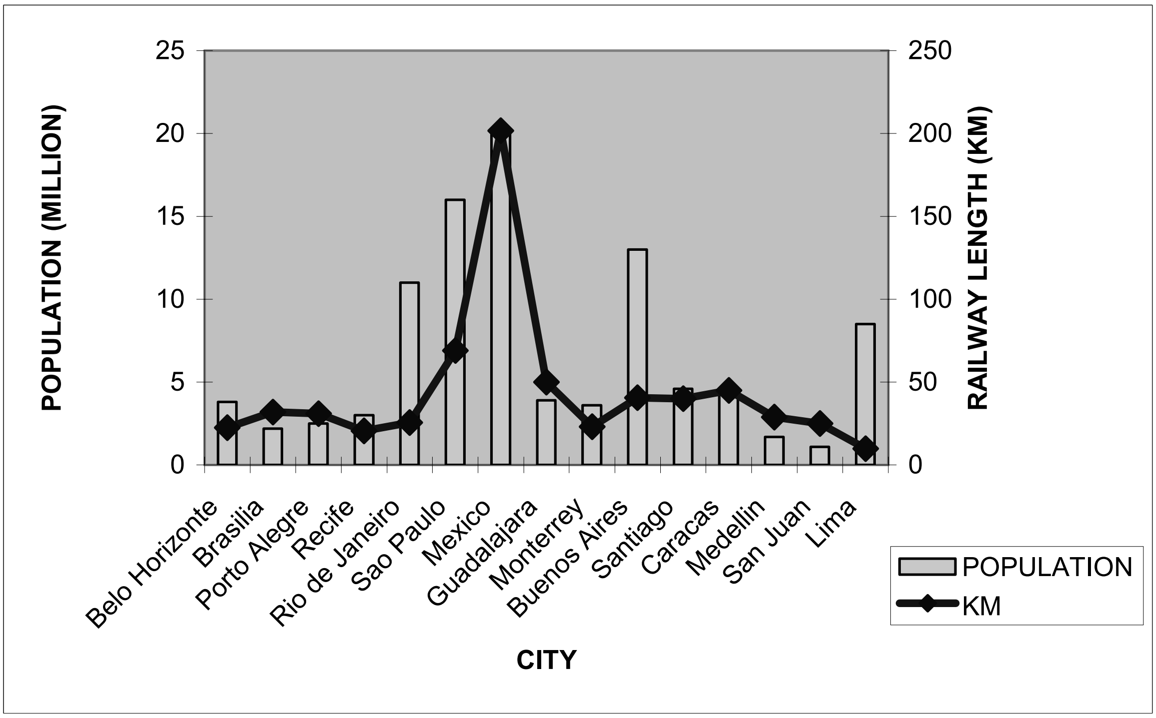


Figure 15.2-2 Comparison of Population in Urban Area and Railway Length

Urban tram transport commenced in 1904 to connect the center of Lima and Callao (north side), Magdalena Del Mar (central side) and La Herradura (south side), which covered the main districts. After 60 years, since 1965, this operation was cancelled due to road congestion and an alternative modernized metro rail system (Government ordinance 15786) was proposed, however, the railway construction program has not advanced at present.

15.2.2. REQUIREMENT OF RAILWAY DEVELOPMENT IN LIMA

The Kyoto Protocol to the United Nations Framework Convention on Climate Change, which has been ratified by Peru on September 9th, 2002, by means of Legislative Resolution Nº 27824 and by virtue of which the states are obligated to assure, individually or jointly, that their added emissions are anthropogenic, expressed in dioxide of equivalent carbon.

In order to give execution to the commitment assumed by Peru, of diminishing and solving the environmental air pollution caused by the crisis in the sector, it transports the establishment of integral measures, not only required at a local level, but also on a national level with the participation of diverse public and private sectors, and of the civil society with the determination of standard, permissible maximum limits, the redefinition of the political tax, the implementation of technical revisions, etc.

The introduction of the urban train in the metropolitan area will facilitate the mass transport use of electric power for the transport of passenger, which will produce a beneficent restructuring of the energy demand, saving consumption of petroleum and the consumption of that energy, at present.

15.3. TECHNICAL CHARACTERISTICS

15.3.1. NATURAL CONDITION

(1) Geography

Peru is divided in three regions: the plain of the Costa, the mountains of the Andes, and the oriental low lands. In the coastal area, narrow and arid areas unite with the Pacific Ocean towards the west and to the hills of the Andes towards the east; it is the region with the highest population density.

The capital of the country is located in the central coast, in a halfway position of the north and south ends of the national territory. The metropolitan area is conformed by the cities of Lima and Callao, stronghold of the main port and airport of the country.

(2) Soil conditions

The soil conditions for the railway structure of the Lima Metro, subject to this study, will use the following parameters:

a) Most of the areas 1.5m below the natural grand level, and in some other cases, will lie on conglomerated material.
b) The load bearing capacity of the grand soil will obtain considerations of more than 40 ton/m^2; this value is enough to support the construction of a viaduct structure and an elevated station building without any piling.

(3) Meteorological conditions

Average rainfall is about 40mm/year, therefore underground depth is 200m and below. The construction of foundation does not require waterproof treatments.

(4) Seismic conditions

The Study area is located in the seismic area of the South Pacific. Since 1568, there are statistics related to the seismic movements in the area, while the instrumental observation with seismographs has started recently in the year 1932. The evaluation of this statistic, and the frequency of the earthquakes, allow us to estimate that an earthquake not smaller than the grade VI of the modified scale of intensities of Mercalli could occur every 12 years in the Study Area. This figure refers to the frequency of the tremors registered in this century. Earthquakes until the grade IX were registered, more or less every 130 years, starting from 1568. During this period, no epicenter has been verified in the Metropolitan Area. All the earthquakes felt in Lima originate in a great flaw structure that runs parallel to the coast, at 60 km.

The grades of seismic danger for Lima, and their different stratum and areas, can be classified into 8 different classes of danger, in accordance with the composition of the different stratum:

a) Artificial fillers, including deposits of garbage like, for example, along the River Rímac, in the districts of San Martín de Porres and Rímac that constitute the areas of more seismic risk.
b) Areas of eolic deposition, like in La Molina and other marginal areas to the South-East of Lima that are critically unfavorable in connection with earthquakes.
c) Areas of loamy saturated slimes, like in Callao and Puente Piedra, equally unfavorable in connection with earthquakes.
d) Areas of sandy alluvial silts, like in the case of Spurts, seismically unfavorable.
e) Areas of contact between the not consolidated silts and the sedimentary or intrusive

rocks.

f) The coastal cliffs, in particular in the areas of fine silts or artificial fillers.
g) Alluvial deposits of gravel, with reasonable and dry dimensional graduation.
h) Solid sedimentary rocks without unfavorable dips, and intrusive rocks, in general, without critical weathering and fallen ruts.

With regards to the "seismic wave", Callao and Bellavista, due to their scarce level above the sea, are susceptible areas, and, therefore, of high risk. This area of Lima and Callao belongs to area 3 of the seismic zone as shown in Table 15.3-1.

Table 15.3-1 Factor of Seismic Zone

Area	Factor of Area Z(G)
3	0.4
2	0.3
1	0.14

15.3.2. DESIGN CRITERIA

(1) Outline of Design Parameters

In the execution of the Line 1 extension, in the aspects related to engineering, civil facilities, supply and installation of the equipment, rolling stock, including auxiliary equipment and spares, and service planning, it must be considered that the existing interface between the technical specification and current standards are as follows,

1) Speeds

   a) Maximum speed 90Km/h
   b) Cruising speed 80Km/h

2) Radius Curvature

   a) Minimum acceptable horizontal curve: 200m
   b) Minimum acceptable vertical curve: 3,000m
   c) Minimum acceptable horizontal curve: 90m (in depot yard)

   (All horizontal curves are jointed spiral transitions)

3) Gradients

   The profile of the track has a maximum gradient of 3.5 % for between stations, and its level (0%) in station. On storage yards, and all of the depot areas also have 0%.

4) Platform lengths and widths

   The length of a 6 coach formation is 120m, including surplus length. The minimum width is 4.0m for sidetrack type and 8.0m for island type. Fixed elements must maintain 2.5m from the edge of the trackside platform. The design density of the platform is 2.0 people per square meter.

5) Platform height

   The platform height is 1.10m from the top of the rail.

6) Distance between platform edge and car-body

   The maximum admissible distance between the edge of the platform and the car-body shall be 10.0cm.

7) Coach Dimension

Maximum Length of a train of 6 cars: 107m
Overall width: 2.85m

15.4. RELATED RAILWAY REGULATIONS

15.4.1. BASIC CONCEPT FOR THE OPERATION OF URBAN RAILWAYS

The AATE is required to prepare the regulation on railway transportation in the metropolitan area by the Ministry of Transportation and Communication under Article 23 of Law N 27181, General Law of Transportation and Land Transportation. The general conditions of the regulations are covered to define the general rules of rail operation and different connected services, as well as the criteria for environmental protection, the interconnection and compatibility of services and relevant technologies.

1) Competencies of the Organization

The Urban Transportation Service serves public requirements and local demands. The related corresponding provincial agencies are engaged in the planning, exploitation and administration stages.

2) Quality of the Service

The railway service provided must supply safety and comfortable travel with cleanliness.

3) Access and Egress to/from Trains

The function of the station will be to provide the easy access and egress through passageways with emergency information services together with measures away from emergency cases.

4) Operational Requirements

The cars will facilitate enough lighting and adequate comfort according to the level of the passenger service.

5) Public Information

The information system will be kept in good condition with clearness, and information signs will be installed inside and outside of the station and cars.

6) Facilities and Equipment of Station Activities

The stations will be maintained duly cleaned and have the following functions:

a) Ticket office
b) Information sign indicating train schedules in each direction
c) Information board with the name of the station in the external front part of the building and platforms
d) Lighting in platforms, passages and stairways
e) Installation of public telephone service
f) Guide indication for movement and evacuation in case of emergency
g) Installation of fire fighting equipment
h) Station announcement for user information
i) Provision of facilities for handicapped people.

7) Communication

The driving cabin is required to have the installation of a communication system for train operation, in order to guarantee a safe and efficient operation.

15.4.2. RIGHT OF WAY

The land purchase for the construction of railway lines tends to be problematic and it influences the project implementation schedule due to lower compensation costs, incomplete resettlement plan, etc. in many foreign countries. However, the characteristic point of the railway network plan in Lima and Callao, including its vicinity area, is that there is a plan to build on existing and/or future road properties. The Municipalities issued the following condition for the construction of Line 1 extension (stage 1).

The Congress of the Republic, (according to article 188 of the Peruvian Political Constitution by Law N° 24565 given on October 30th 1986), has delegated in the Executive Power the faculty to dictate Legislative Decrees by the term of 180 days for ruling the establishment of the Electric Mass Transport System for Lima and Callao, matter of Supreme Decree N° 001-86-MIPRE, which has been given force of Law.

That the delegated faculties given according to what is stated in the above paragraph, are referred to the right of way use of the public way and to the authority to execute the necessary expropriations that are required for the construction of the infrastructure of the Electric Mass Transport System for Lima and Callao.

That it is necessary to expedite the specific norms referred to the Right of Way use of the public way which is referred in article 2 literal b) of Law 24565 with the approbatory vote of the Council of Ministers, has given the following Legislative Decree:

Article 1: Authorize the Autonomous Authority of the Special Project of Electric Mass Transport for Lima and Callao (AATE), the Right of Way use of the public roadway according to the following indicated detail, which can compromise private, fiscal or public use properties, with an 18-meter wide way from which 8 meters are for the exclusive use of lines, reserving the other 10 meters for required probable infrastructures for the station, according to what is consigned in Article 2.

Article 2: This authorization includes the use of avenues, streets, plazas, green areas, medians of the road system and other state or community properties of public use that are necessary, as well as soil and subsoil use located within the vertical planes of the corner border of those areas up to being useful. Whatever the case is, the AATE will coordinate with the Provincial Councils of Lima and Callao, the Urban Development Direction and the National Culture Institute, the more adequate solutions for the goals of the urban railway and the utilization of those properties preserved as State Monumental Patrimony as well as the optimization of areas for the best use of the way.

Article 3: AATE, ordered by a Supreme Resolution, can point out other dimensions that could be required for the use of public way, previous coordination with the Urban Development Direction of the Municipality of Lima.

Article 4: This Legislative Decree will be refrained by the Minister of the Presidency, the Minister of Transportation and Communications and the Minister of Housing and Construction.

15.4.3. MAINTENANCE SYSTEM OF FIXED INSTALLATIONS

The maintenance of fixed installations is generally regulated as follows,

a) Superstructure of way, in the main line and in the depot.
b) Electric lines and electric substations
c) Sign system and automation of electric distribution
d) Telecommunications

e) Equipment of station for the service to the passengers.
f) Hydraulic equipment
g) Building works and civil structure

The maintenance will be in charge of teams of people who will work lengthwise in the railway and in the interior of the installations.

Each installation will be subject to a particular conservation; therefore, it is convenient to make evident the more important phase, as per example the maintenance correspondent to the superstructure of the railway and to the electric line.

To guarantee a good preservation of the railway facilities, a series of operations will have to be carried out, included in the common systematic preservation in the field, which is based on general periodic controls, and the forecast of two characteristic phases as the systematic leveling of the track and the general revision of the track.

The revision cycle has a period of four years, normally; therefore, the line is divided in four zones. A general revision is carried out in each zone during one year of the four year period. The parts which are not subject to revision are provided with systematic leveling.

The maintenance of the electric installation is equivalent to a good preservation of the contact line and of the return circuit and the earth of the line.

15.5. EXISTING RAILWAY CONDITIONS

15.5.1. STANDARD CONDITIONS

Italian standards are applied to the dimensions of the construction gauge, however, the passage way (about 60cm) for maintenance and shelter is not a space for the reduction of construction costs. It is recommended to examine the provision of this space for the next stage of the extension. The general condition of railway criterion is shown in Table 15.5-1.

Table 15.5-1 Standard Conditions

Items	AATE	Tokyo Metropolitan Railway (Line 1)
Track Gauge (mm)	1,435	1,435
Current collection Method	Aerial Line	Aerial Line
Power Source (V)	1,500 DC	1,500 DC
Length of rolling stock (m)	18.0	18.0
Rolling stock gauge (width x height: mm)	2,850 x 3,470	2,800 x 3,886
Construction gauge (width x height: mm)	3,200 x 4,750	3,200 x 4,800
Minimum radius curvature: (m)	200	160
Maximum gradient: (mm)	35/1,000	35/1,000

Note: AATE is currently analyzing the gauge of both rolling stock and construction for the introduction of worldwide standards.

15.5.2. SCALE OF DEPOT

(1) Area of Depot 144,000 m^2 (for a 220 coach capacity)

The depot space was designed for a 220 coach capacity, 164 coaches for the 2 minute operation headway for the planned scheduled operation in 2040 and for the rolling stock of commuter operations of Line 1 and part of other lines when the through operations between lines begin.

(2) Function of the Depot

The main function of the depot is that it serves for the maintenance and repair works of the rolling stock, track, electric and mechanical equipment as mentioned below.

a) Maintenance and inspection shop
The first sector is to implement regular maintenance (preventive maintenance and minor repairs) and car cleaning.
The second sector is to implement general overhaul and major repair works.

b) Fixed Installation Building Maintenance Service
This works contains the service premises for the maintenance of fixed installations, and also the dressing rooms and sanitary services for personnel.

c) General store
There is a main building for the general store in which a vault has been constructed for the custody of securities, as well as providing the necessary equipment for its functioning.

15.5.3. PRESENT CONDITIONS OF EXISTING RAILWAY (LINE 1)

(1) History of Line 1

The Supreme Ordinance 001-86 MIPRE was issued, declaring the establishment of the project a public necessity and a preferable social interest in 1986, with the purpose of endowing the population and outlying high density areas of Metropolitan Lima and Callao with a transport infrastructure for the quick mobilization of its population, creating the AATE in charge of the planning, coordination, supervision, control and execution of the electric urban transport, with complete technical, administrative, economic and financial autonomy.

In 1990, the construction of line 1 with full-dress of the urban railway line had commenced with the financial support of the Italian government under the supervision of AATE. The first section of 9.8 Km of Villa EL Salvador ~ Atocongo, including a depot at Villa El Salvador, was commenced until 1993. This financial cost consists of US$100 million (Italian Government loan and grant) and US$ 114 million (Peruvian Government). However, the extension of the remaining section is postponed due to a lack of financial support and a drop of the party.

(2) Present Activities of the Line Extension Project

The Municipality of Lima created an administrative and executive entity related to Transport on February 2003 (Municipal by-law No.092) to solve problems concerning urban transport in the metropolitan area. Said entity, named the Metropolitan Lima Transportation Committee TRANSMET, integrates the policies concerned with transport previously carried out by several institutions of the Municipality.

The extension of lines 1 & 2 was selected as an urgent implementation project. The selection of investors for Line 1 is currently in progress, and the feasibility study of Line 2 is also in progress. When the concession contract of Line 1 is completed, the staff working in the field will be transferred to the concessionaire from AATE's present organization.

15.6. BASIC STRATEGY OF RAILWAY PLANNING

15.6.1. IMPACT OF URBAN RAILWAY TRANSPORT

The Metropolitan areas have always been centers of human activities. They have been central locations for manufacturing, trade, education, culture, and other activities. Most of them check their moving time on their trips. Other foreign countries, which have introduced the urban rapid train system, have usually had city planning. The rapid train did get better treatment; therefore, its stations were used as focal points for the street network and for feeder transit convergence. Various commercial and office complexes and other intensive land use have often built around the stations, because they can read time by the use of the urban rapid train for their trip purposes. Therefore, the secondary and tertiary sectors are concentrated in the station service area as a result of the impact of the urban railway system.

The great impact that urban railway development has had on modern civilization is also evident: the intensive urbanization that has taken place in all countries would not have been possible without a modern transport system.

The problems of developing a railway system are mostly the consequence of various deficiencies in the planning, financing, and operational organization of urban transport. Nevertheless, the historical developments clearly show that there is a strong interdependence between the quality and type of transportation services on one side, and urban form, size and character on the other. Municipalities have often failed to understand the role of transportation, specifically in the case of the poor development of urban transport policies.

Although the nature of contemporary urban transportation problems varies among the different cities and countries, their general causes have many common elements. For example, most large cities in developing countries suffer very seriously from poor mobility, pollution, noise, daily traffic accidents, and economic waste caused by chronic traffic congestion. This condition is often a consequence of the failure to ensure an acceptable level of transport service through the separation of this mode from other traffic.

15.6.2. CREATION OF AN INTEGRATED PUBLIC TRANSPORT NETWORK

Railway stations serve to provide transportation services, as the front door of a station service area and core transportation area and life of urban activities. Many citizens carry out activities that force them to commute (business and/or school), house works, daily business activities and leisure, through each station.

Presently, public transportation is mainly dependant on several kinds of buses and taxis in Lima. However, when considering that the scale of Lima and the metropolitan area includes Callao and its suburban area, it is required to develop more balanced public transport networks between railways and buses, including a feeder mode network.

Figure 15.6-1 shows the relation between railway stations and bus stop for creating an integrated transport network, the station should also be provided with ticket gates, a ticket office and a concourse on the second level for grade separation of passengers and vehicles.

The pedestrian bridge will be located on the same second level, connecting to each corner of the crossing and a bus-way station, if any. The railway station should be developed with a bus-way station, bus terminal, bicycle parking, car parking, taxi stand, commercial building and cultural facilities etc.

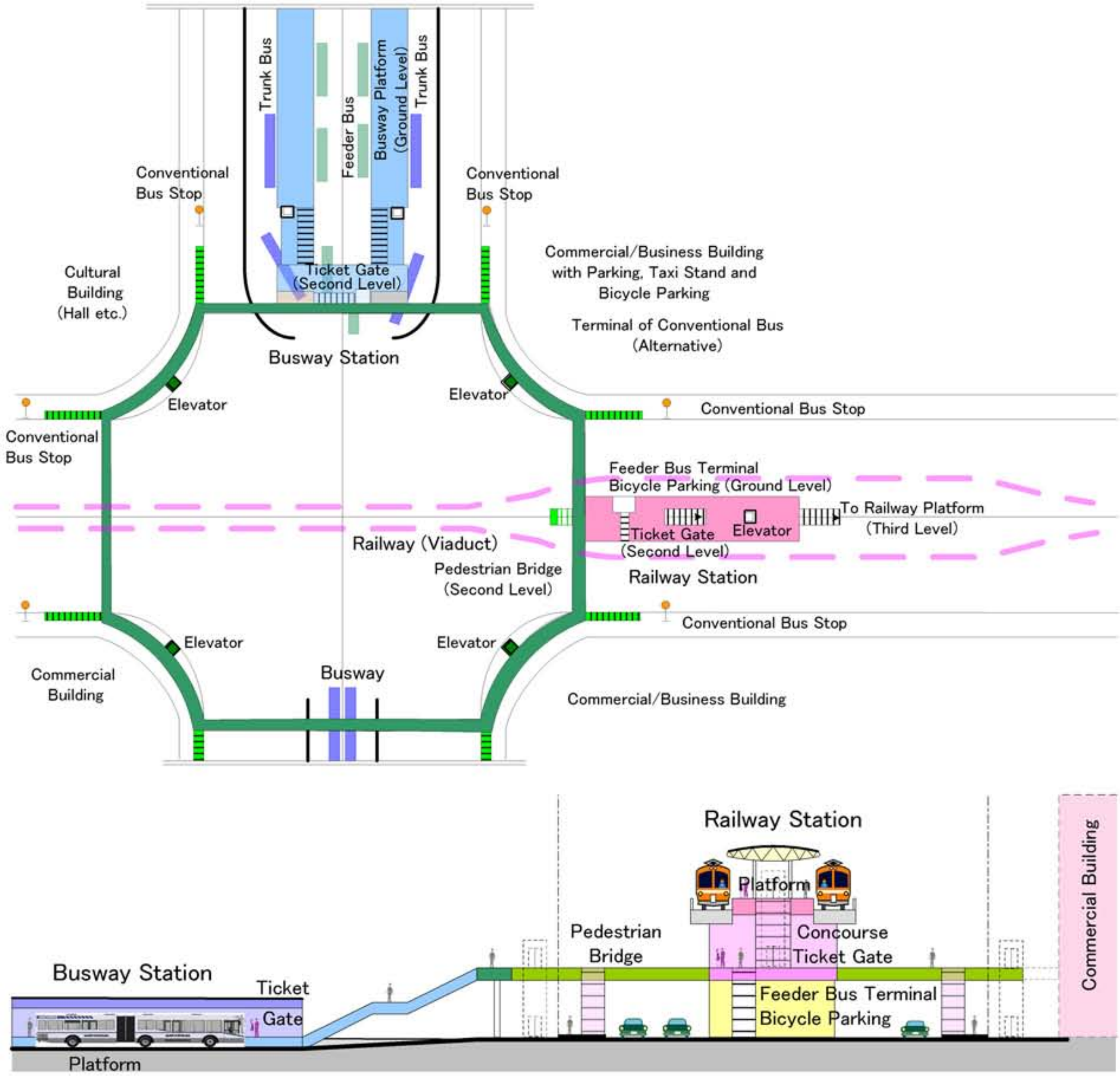
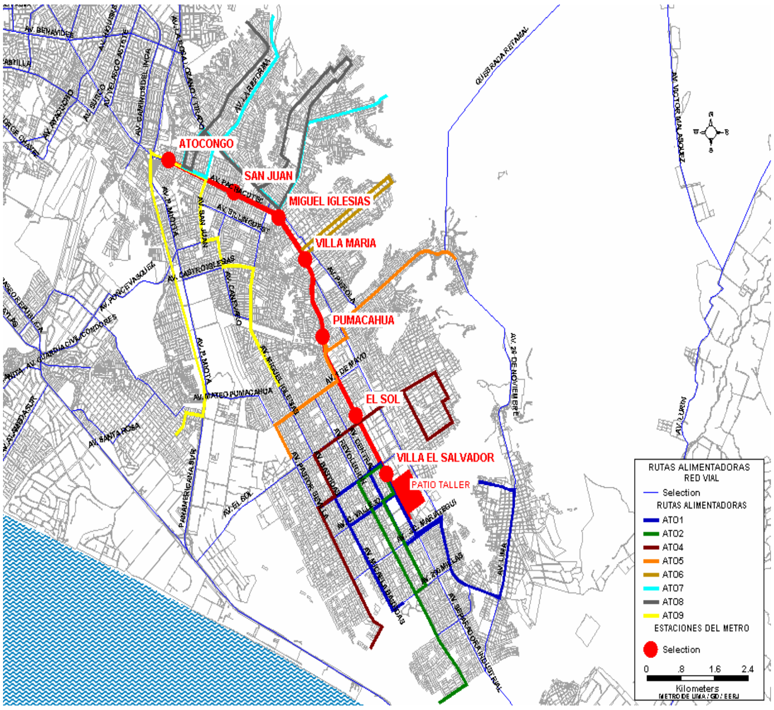


Figure 15.6-1 Conceptual Plan for the Connection of Railway Station and Bus Stop

Also, for the expansion of the station service area, it is required to provide feeder services between stations and a connection with the vicinity area. Figure 15.6-2 shows a basic idea of the feeder service.



Provided by AATE

Figure 15.6-2 Option of Feeder Service

15.6.3. Railway Related Business

The establishment of railway related businesses requires a massive investment cost in the initial stage for the construction of railway facilities, such as civil structure, signals & communication, and for the procurement of rolling stock with its maintenance facilities, etc. Also, when the railway operation begins operation and maintenance expenses are required to maintain the punctual operation and safety of the transport service. However, it is an impracticable plan to setup transport fares correspondent to their expenses. Therefore, it is necessary for railway enterprises to expanding their railway related businesses; it is today's political wind in the world. The basic idea detailed below.

The vicinity area of the station will obtain high benefits from railway users; therefore, it is required to create a knot between the railway station and its vicinity area

a) Reinforcement of the function of the transportation interchange
b) Level up of the feeder service into the station service area
c) Creation of a land use plan for commercial and business functioning in the city center
d) Land use plan of houses along railway corridors in the suburb

In consideration of such characteristic mentioned above, railway business can be developed, not only depending on the revenue from passenger fares, but also from railway related businesses as mentioned below.

1) Transport business
    a) Bus, taxi, rental car, etc.
2) Real estate business
    a) Development of residences, buildings, sales and rental business, etc.
3) Commercial distribution business

a) Department store, retail store and shops

4) Travel and leisure business

a) Hotel, travel agency
b) Theme park, movie-theater, sports center, etc.

5) Construction and Manufacturing

a) Civil, building, electric works, gardening, car maintenance & repair works, furniture manufacturing, etc.

6) Culture

a) Technology school, library, museum, publisher, etc.

7) Other Service

a) Maintenance, security guard, parking, etc.

15.6.4. SUBSIDIES FOR CONSTRUCTION OF URBAN RAILWAY LINE

The public transportation system is the real infrastructure of urban activities.

(1) Energy efficiency

The comparison of energy efficiency by transport mode by discharge of carbon dioxide, private car is 7.5 ~ 9.0 times, ordinary bus is 2.5 ~ 5.6 times higher than heavy railway in Japan. These results influence the environmental pollution. Figure 15.6-3 shows the discharge of carbon dioxide.

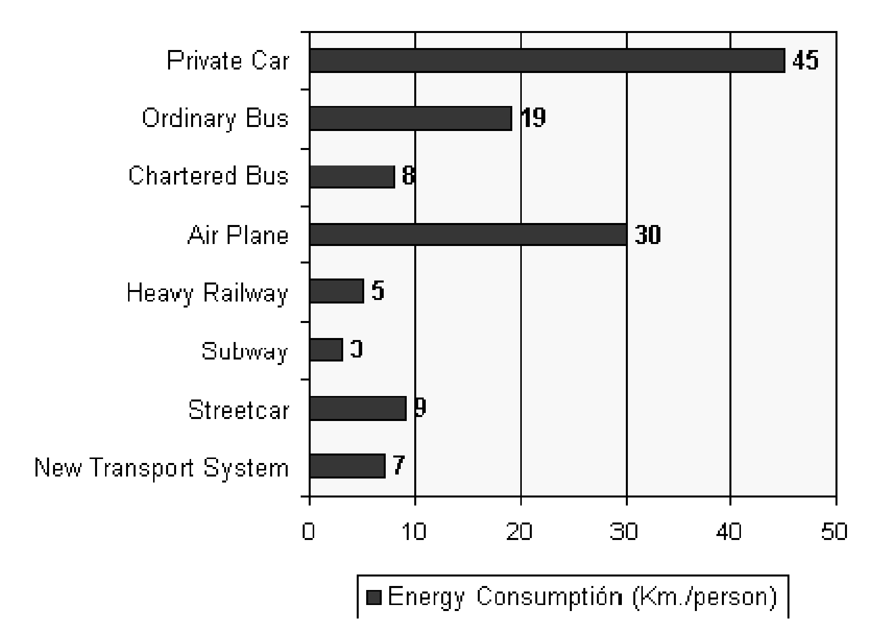


Figure 15.6-3 Unit of Discharge of Carbon Dioxide

(2) Space occupancy

For the comparison of occupancy ratio in the urban area, it is calculated under the assumption that the space is equivalent to double railway tracks and two road lanes. The railway occupancy is 16,000 passengers/hour/m, while the road occupancy is 650 persons/hour/m (only private car use). This result shows that the railway is more efficient than cars, especially in high-density urban areas.

(3) Saving of Daily Travel Expenses

The price of gasoline is increasing in the world. The gasoline price in Lima is about 12~13 soles per gallon, this price is almost the same as in Japan, under this condition, this expense is affecting the household income, since the expense of commuting travel is a personal expense. It is assumed that the average expense for travel cost is around 15~20% of the household expenses.

Although railway transportation has several advantages, not only urban transportation but also long distance operations, the development and improvement of railway projects requires huge initial investment costs, therefore, the Japanese government provides various kinds of subsidies for the development and improvement of the railway system. Table 15.6-1 shows the subsidy system in Japan.

Table 15.6-1 Subsidy System in Japan

Type/method of subsidy	Operating organization	Detail of subsidy
Metro method	Tokyo Metro Municipal Metro	70% of the construction cost is equally funded by central and local government in 10 years starting in the first year of construction
New town line method	National housing development corporation, Municipal, Public organization, Third sector	36% of the construction cost is equally funded by central and local government in 6 years starting in the first year of operation
Infrastructure assistance method	Municipal or third sector for monorail	Infrastructure construction cost (maximum 44.9% of total construction cost) is funded by the government (2/3) and municipal (1/3). 20% of other than infrastructure cost might be funded by municipal.
Metropolitan transport infrastructure improvement	JR	35% of construction cost will be funded in 10 years by the government for the improvement of urban commuter transport available only in 14 largest cities
Railway infrastructure improvement subsidy	Private railway third sector	Government and municipal will compensate annual operating loss for superannuated but inevitable for residence loss making railway
Level crossing system improvement subsidy	Private, JR, Third sector	Government will fund 1/2 and municipal will fund 1/3 of the safety improvement cost of level crossing

Table 15.6-2 also indicates the subsidy of construction and operation in other foreign countries. Because such subsidies are born from judgments of social benefit, in consideration of alternate expense is higher than subsidies to railways.

Table 15.6-2 Subsidies in Foreign Countries

	Name of Cities	Share of subsidies							
1	Paris	60%	Government	40%	Firms				
	Hamburg	60%	Federal Government	40%	Firms				
	Munich	60%	Federal Government	20%	Municipal, State	20%	Firms		
	Stockholm	95%	Government	5%	Firms				
	San Francisco	35%	Federal Government	30%	Region	13%	State	22%	Local
2	Paris	36%	Fare revenue	10%	Other income	13%	Local	41%	Urban Transport Tax
	Hamburg	75%	Fare revenue	25%	State, Federal Gov				
	Munich	50%	Fare revenue	50%	City				
	Stockholm	41%	Fare revenue	59%	Public Transport Tax				
	San Francisco	42%	Fare revenue	7%	Other income	4%	State	47%	Specific Tax (Petrol Tax, VAT)

Note: 1. Subsidy for construction expenses. 2. Subsidy for operation and maintenance expenses

15.7. FUTURE RAILWAY DEVELOPMENT PROGRAM

15.7.1. RAILWAY NETWORK PLAN

The railway network plan and stage implementation plan is prepared making reference to studies and discussing and approving ideas with the AATE. The proposed commuter trunk railway line consists of seven lines covering metropolitan Lima and Callao together with its vicinity area. This railway network planning only covers the metropolitan area, however, it is recommendable to consider the extension to the suburban area as a middle distance train operation system in the future with the evaluation of the movement of passenger demand.

The main function of each line is summarized in Table 15.7-1 and the lines are shown in Figure 15.7-1.

Table 15.7-1 Line Characteristic

Line	Characteristic
Line 1	Creation of North-South corridor (33.90km) The line purpose is to create a north-south corridor traveling through the city center starting from Villa El Salvador ~ Atocongo (existing section) ~ Hospital 2 de Mayo (ongoing section) and reaching Bayovar (planed section) in San Juan de Lurigancho..
Line 2	Creation of East-West corridor (29.00km) This line connects Garibaldi, in Callao, and Las Torres. Presently, the feasibility study on commuter services is being implemented through the financial support of the US TDA for the purpose of creating the east-west corridor.
Line 3	Creation of Circular Operation (28.10km) This line aims to create a circular operation which connects line 2, Garibaldi in Callao and S. Industrial. The main purpose of this line is the reduction of chronic traffic congestion on Av. Javier Prado.
Line 4	Reinforcement of the North Railway Corridor (24.60km) This line connects Faucett in San Miguel (connects to Line 3) and Carabayllo in the district of Comas passing through Jorge Chavez International Airport. The road traffic flow between the north district of Comas /Puente Piedra and the city center will be reduced by the construction of this line.
Line 5	Complementary Railway Corridor for the North and South (26.60km) This line running abreast of the Pan-American highway from the district of Puente Piedra is located on the north side through the city center and reaches Atocongo with the use of some sections of the existing Line 2. This line will be constructed when the bus operation is paralyzed by the road traffic congestion on this route.
Line 6	Complementary Transport for Line 2 and Line 3 (24.40km) The function of this line is proposed as complementary to both lines and for the reduction of traffic congestion on this road.
Line 7	Complementary Railway Corridor for the North and South (km) This line will begin construction when the bus transport capacity has reached its margin of capacity.

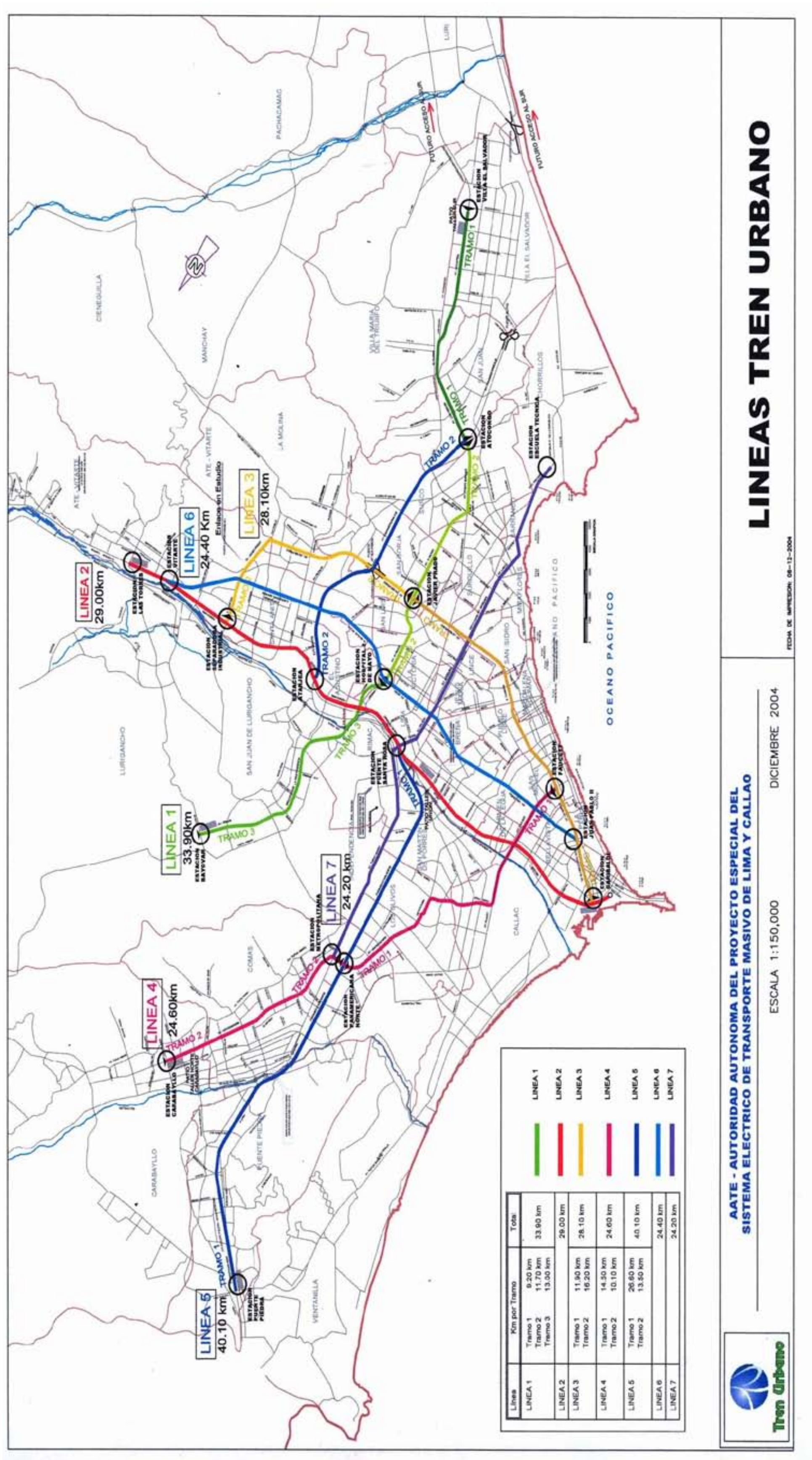


Figure 15.7-1 Urban Railway Lines

15.7.2. RAILWAY DEVELOPMENT NETWORK PLAN UNTIL 2025

In previous chapter 12 of this report, total fifteen (15) alternative Transport Network in the study area is examined. As the results of examination, the Alternative Transport Network Plan – N is selected. The Alternative Transport Network Plan – N is formed at four (4) railways lines such as Line-1 to Line-4 and fifteen (15) trunk bus routes.

The railway development network plan until 2005 is nominated to be carried out from Line 1 to Line 4 due to the scale of investment cost of this master plan. However, it is necessary to review the investment plan in consideration of the demand of railway transport and the public transport policy. Table 15.7-2 shows the recommended construction plan by stages and Figure 15.7-2 shows the location of each line.

Table 15.7-2 Stage Development Plan

Line	Section
Line 1	1st stage: Constructed (9.2km) 2nd stage: Atocongo - Hospital 2 de Mayo (11.7km): On-going 3rd stage: Hospital 2 de Mayo - Bayovar (13.0km)
Line 2	Garibaldi – Las Torres (29.0km)
Line 3	1st stage: Garibaldi - Javier Prado (16.2km) 2nd stage: Javier Prado - S. Industrial (11.9km)
Line 4	1st stage: E. Faucett – Panamericana Norte (14.5 km)

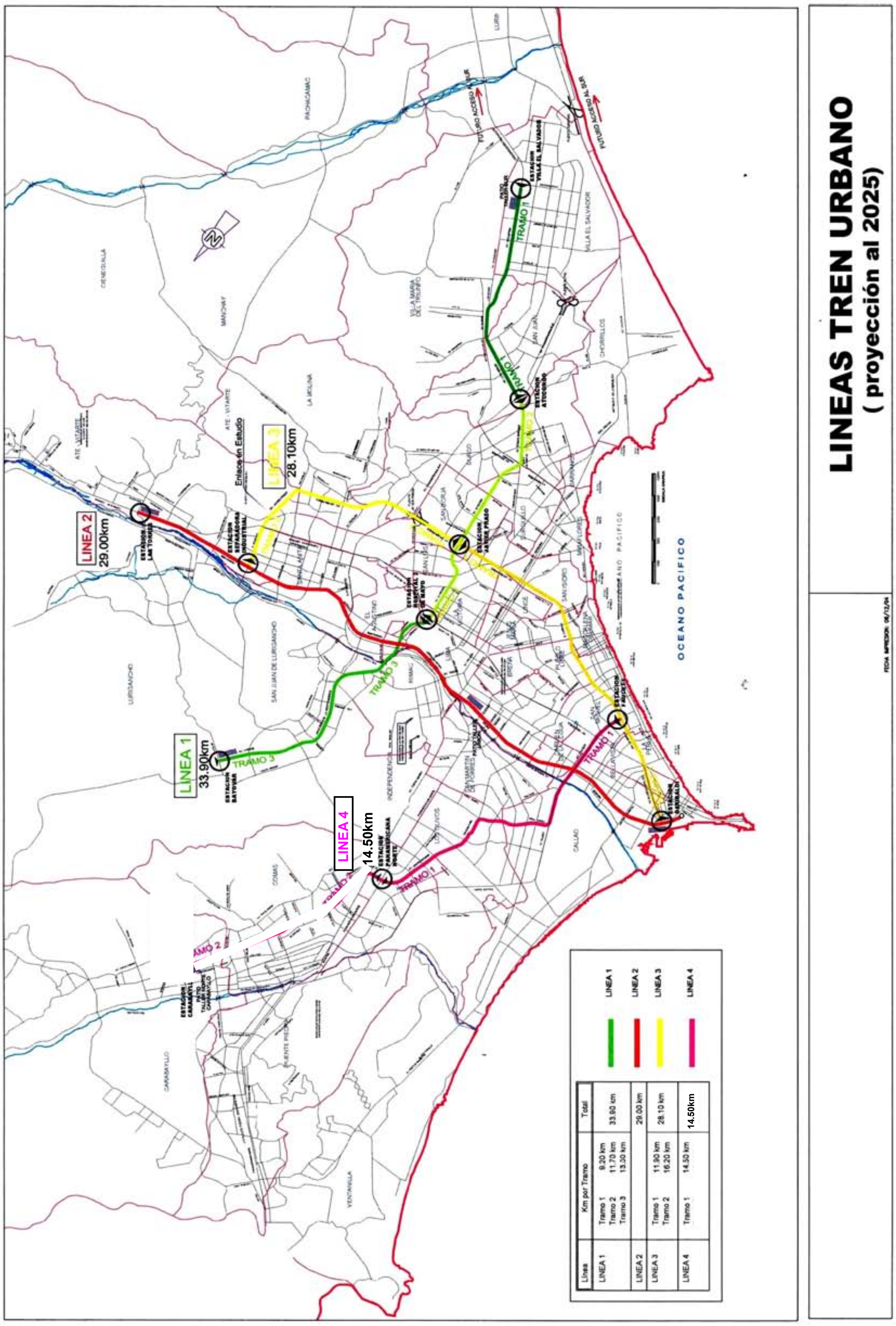


Figure 15.7-2 Railway Development Network until 2025

15.7.3. RAILWAY DEVELOPMENT OPERATION SYSTEM

The railway operation system is examined based on the Alternative Transport Network Plan-N selected in Chapter 19 of this report. The transport network of Alternative Plan-N is mainly formed by four (4) railway lines and fifteen (15) trunk bus lines. The trunk bus operation systems include the trunk bus system, original bus system and feeder bus system.

(1) Railway Operation System

The major future transport system in the study area will be formed by railway transport, bus transport (such as omnibus transport), microbus transport, camioneta transport, and trunk bus transport, as well as private transport. In the previous section, the future bus operation system is recommended to form the original bus, feeder bus, and trunk bus operation systems.

In this section, the relationship between the railway transport system and the following transport systems is examined.

a) Railway system and existing bus system
b) Railway system and feeder bus system
c) Railway system and trunk bus system
d) Railway system and railway system

1) Relationship between Railway System and Existing Bus System

As shown in Figure 15.7-3, the existing bus is operated in accordance with bus passenger demand on the existing arterial, collector and local roads. When the railway is operated, the following railway operation system is required to create an effective comprehensive transport system, to mitigate traffic congestion and to ensure good environmental aspects in the Study area.

The existing bus routes, which will operate on the same road of the railway route, will be relocated to other roads.

The existing bus routes should be connected to the railway station to ensure the effective comprehensive transport system as shown in Figure 15.7-4.

It is necessary to introduce the Integrated Fare System between the railway and existing buses on the railway stations and terminals to ensure the smooth transfer between the two systems.

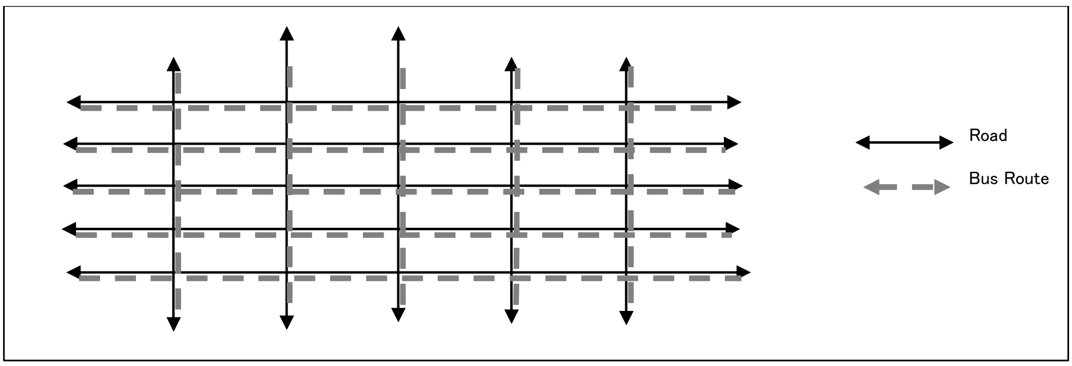


Figure 15.7-3 Existing Traffic System

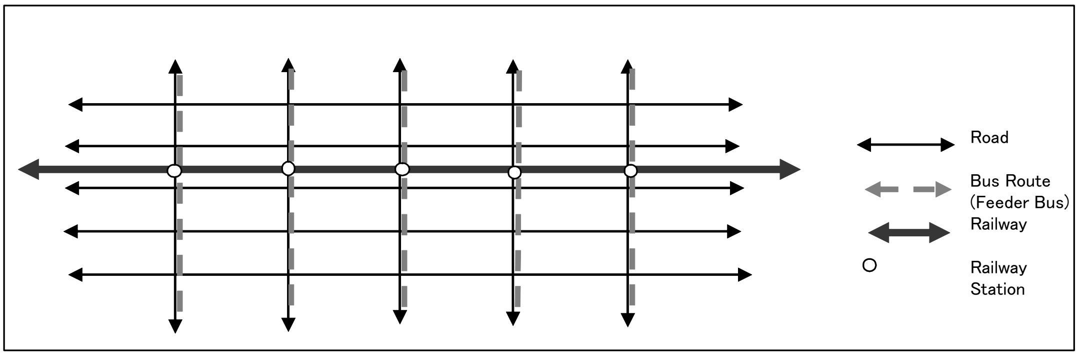


Figure 15.7-4 Relationship between Railway System and Bus System

2) Relationship between Railway System and Feeder Bus System

The following aspects are required in order to operate the railway transport and feeder bus transport,

The feeder bus should be connected to each railway station and railway terminal in order to consider the accessibility of passengers as shown in Figure 15.7-5.

The feeder bus routes should be covered with surrounding areas of railway stations and railway terminals.

The feeder bus should be maintained as a supporting transport system of railway transport.

It is necessary to introduce the Integrated Fare System between the railway and feeder buses on the railway stations and terminals to ensure the smooth transfer between the two systems.

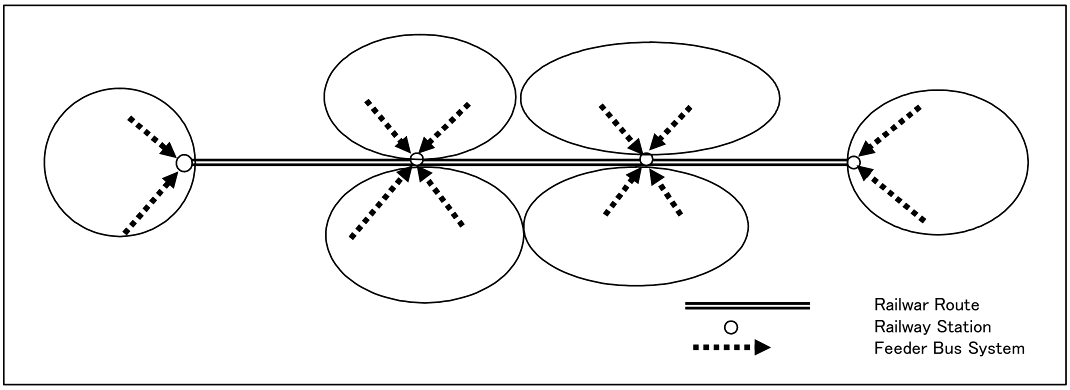


Figure 15.7-5 Relationship between Railway and Feeder Bus System

3) Relationship between Railway System and Trunk Bus System

The following aspects are required in order to operate the railway transport and trunk bus transport,

The trunk bus routes should not be located in parallel to railway routes.

In the future, it is necessary to introduce the Integrated Fare System between the railway and trunk buses on the railway stations to ensure the smooth transfer between the two systems.

4) Relationship between Railway Systems

In the Long Term Plan, four (4) railway lines such as Line-1, Line-2, Line-3, and Line-4 are recommended. Line-1 is connected at Line-2 and Line-2 is connected at Line-1, Line-3, and Line-4. The operation organization is not decided yet, however, the change of the railway line should be introduced by the Integrated System.

(2) Railway Passenger Demand

The peak hour railway passenger demand in 2025, by railways projects, is presented in Table 15.7-3. The detailed methodology and number of passenger are described in Chapter 21 of this report.

From Table 15.7-3, the following passenger characteristics are pointed out.

a) The percentage of inbound and outbound passengers in 2025 is approximately 51% and 49% respectively.
b) The maximum number of peak hour passengers in 2025 is observed at 65,000 passengers in the nearby areas of the Center of Lima.
c) The number of peak hour passengers in 2025 from San Juan de Lurigancho to the Center of Lima is estimated at 59,000 persons.
d) The maximum number of peak hour passengers in 2025 (59,000) from San Juan de Lurigancho to the Center of Lima obviously exceeds the transport capacity of the trunk bus transport system.
e) The maximum number of peak hour passenger on each railway line in 2025 obviously exceeds the transport capacity of the trunk bus transport system.

Table 15.7-3 Passenger Demand on Line-1 Project

Railway Route Segments	*Peak Hour Passenger Demand in 2025*	
	Inbound (persons/hour)	*Outbound (persons/hour)*
Line-1 (1)	39,000	*37,000*
Line-1 (2)	55,000	*61,000*
Line-1 (3)	35,000	*59,000*
Line-2	65,000	*59,000*
Line-3 (1)	35,000	*22,000*
Line-3 (2)	19,000	*16,000*
Line-4	*42,000*	*17,000*

(3) Railway Transport Capacity

The railway transport capacity per hour and per direction is calculated depending on the following transport conditions.

a) How many passengers fit in one (1) coach (size of coach).
b) How many coaches are required for one (1) train (length of train).
c) How many times a train can be dispatched during one hour (operation frequency).

In this section, the railway transport capacity per hour and per direction is calculated based on the various transport conditions. The results of the railway transport capacity calculation are presented in Table 15.7-4.

In Table 15.7-4, the following transport capacity is identified.

a) The transport capacity is estimated at 60,000 passengers per hour and per direction based on 250 persons per coach, 10 coaches per train and a 2.5 minute operation frequency.
b) When the number of coaches per train is reduced from 10 coaches to 6 coaches, the transport capacity is estimated at 36,000 passengers per hour and per direction.
c) When 15 coaches per train are introduced, the transport capacity can be increased.
d) Considering the train operation system, loading and unloading times of the train and transport safety, a 2.5 minute operation frequency may be the minimum time.

Table 15.7-4 Railway Transport Capacity based on Different Conditions

Transport Mode	Number of Passengers per Coach (Persons) (A)	Number of Coaches per Train (Units) (B)	Number of Passengers Per Train (Persons) (A)*(B)=(C)	Operation Frequency (Minutes) (D)	Operation Times per Hour (Times) 60/(D)=(E)	Transport Capacity per Hour per Direction (Persons) (C)*(E)=(F)
Railway Transport	250	10	2,500	2.5	24	60,000
				4	15	37,500
				6	10	25,000
				10	6	15,000
	250	8	2,000	2.5	24	48,000
				4	15	30,000
				6	10	20,000
				10	6	12,000
	250	6	1,500	2.5	24	36,000
				4	15	22,500
				6	10	15,000
				10	6	9,000

(4) Railway Operation Frequency

The railway operation frequency is examined basically to compare it with the number of estimated passengers and the transport capacity of each transport condition mentioned above. In addition, the operation cycle time of the railway line should be considered. As the result of the operation frequency examination, the summary of the peak hour operation frequency by railway line is shown in Table 15.7-5.

Table 15.7-5 Summary of Peak Hour Railway Operation Frequency

Main Railway Line	Maximum Volume (persons/hour/direction)	Number of Coaches/ Train (Coaches)	Headway or Frequency (Minutes)	Remarks
Line-1	61,000	10	2.5	254 person/coach
Line-2	65,000	10	2.5	270 person/coach
Line-3	35,000	6	2.5	240 person/coach
Line-4	42,000	8	2.5	220 person/coach

(5) Railway Station and Terminal

On the railway station and terminal, railway transport is connected by the trunk bus, feeder bus, original bus transport and other transport modes, such as walking, bicycle transport, taxies, and private passenger transport,, for changing the transport network. Therefore, many passengers are gearing to the railway station and terminal. Considering the abovementioned activities, the station and terminal function as a very important facility and the following spaces and functions should be required.

a) Parking and transfer spaces for bicycles, taxies, passenger cars and buses.
b) Operation office and equipments space
c) Open space for users.
d) Shopping space and resting space.
e) Hotel space, if possible.

In addition, large-scale shopping center development plans or re-development plans in front of stations and terminals should be carried out to promote the increasing number of passengers for the railway system, to construct the sub-city center of the study area, as well as to create the modern city.

15.7.4. ADEQUATE TRANSPORT MODE (HEAVY RAIL / LIGHT RAIL)

(1) Definitions and Characteristics of Transport Modes

The railway network is prepared for the creation of commuter services in the metropolitan area. However, Light Rail Transit Systems were proposed by previous studies. In this section, we will try to clarify the definitions and characteristics of heavy rail and light rail.

a) Heavy Railway System
This system is called the Urban Rapid Transit System, it represents the optimal transit mode for a high-capacity demand line, and the present Line 1 system is introduced to this system. The operation is fully segregated by the right of way, without any interference. Simple guidance, electric traction, and fail-safe way control allow the maximum speed possible with given station spacing and permitted by passenger comfort, high power utilization efficiency, high reliability, and virtually absolute safety. The rapid transit system is usually elevated and/or in a tunnel in a central urban area while aerial structures, embankments, and some section at grade are common for suburban and outlying areas.
b) Light Rail Transit System
This system consists of electric powered, high capacity, quiet vehicles with high riding quality operation in approximately 1 to 5 cars in a train formation on a predominantly separated right of way. By its performance/cost characteristics, LRT falls between Streetcars and Heavy Rail modes. LRT vehicles may be required with low-level step high at present, public address and communication systems as well as a signaling system when operation frequencies are dense. LRT operates substantially on the exclusive right-of-way, which sometimes introduce grade separated structures. Light Rail mode is increasingly introduced in urban transportation as a complementary transport mode.

(2) Selection of Mode with Comparison to Demand

The result of demand forecast on each line has been provided for 2025. For the train operation planning and estimation of required No. of train sets, the condition of calculation is introduced by using the following hypothesis,

a) Train operation headway: 2.5-minute headway (Existing train control system of Line 1 is designed for 2.0 minute headway; however, this hypothesis introduces safety factor turn-back operation at terminal station).
b) 6 coaches are presently introduced for a maximum train formation, but a 9 coach formation (160m) is possible to correspond to the future transport demand.

Table 15.7-6 shows the transport capacity for heavy railway and light rail, which was obtained from AATE.

Table 15.7-6 Transport Capacity

Transport Capacity	Heavy Railway System				Light Rail
	M1	M2	T	Total	
Capacity (3 Coaches)	246	260	260	766	750
One train (6 Coaches)	492	520	520	1,532	1500
One train (9 Coaches)	738	780	780	2,298	No

Motor car (1) Motor car (2) Trailer car

Table 15.7-7 calculates the train operation headway of light rail for 3 coaches and 6 coaches.

Table 15.7-7 Preliminary Operation Planning (LRS)

LRT	Line 1	Line 2	Line 3	Line 4
Route Length (Km)	33.9	29	28.1	24.6
Operation Length (Km)	67.8	58	56.2	49.2
Nº of passenger in Peak Hour (Person)	61,000	65,000	35,000	42,000
No .of train Sets (3 coaches)	82	89	49	56
Train Operation Head (minute)	0.73	0.68	1.29	1.09
No .of train Sets (6 coaches)	41	44	24	28
Train Operation Head (minute)	1.46	1.36	2.5	2.4

The result of the calculation to estimate the required train sets, following the demand forecast result, indicates that the light railway system is not recommendable due to its transport capacity. The total cost of a uniformed system for each line is more economical because the systems are compatible with each other.

15.7.5. OPERATION PLANNING

Although the technical designed operation headway is 2.0 minutes, 2.5 minute headway is introduced for the estimation of the required No. of rolling stock in consideration of the required time as a safety factor at turn-back operations at both dead-head stations. However, it is recommended to introduce about 15.0 to 10.0 minutes of headway during peak hours at the beginning stage to reduce the initial investment cost and provide a minimum frequency requirement of commuter service.

The railway network is considered to be created as a complementary function through the coordination of each line; therefore, investment timing of each line will require the reflection of the railway transport demand. In addition, it is recommended to introduce a flexible time for the reduction of the peak ratio, especially the morning commuting time, as an alternative.

For the construction of Line 1, Stage 1 has already introduced the idea to procure secondhand coaches for reducing the total investment costs. It is recommendable, since the cost proportion of coaches will be a high share of the total investment cost; some countries have already introduced this idea in order to continue rail-base commuter services, such as Buenos Aires in Argentina.

15.8. IDENTIFICATION OF NETWORK DEVELOPMENT PROJECTS

15.8.1. Description of Each Railway Network

Table 15.8-1 to Table 15.8-7 shows the project description for each line.

Figure 15.8-1 to Figure 15.8-4 shows the location of railway line.

15.8.2. Project Cost Estimate

The construction method, especially civil works, influence the estimation of project cost, however, the cost estimation of this Master Plan is mainly based on AATE's investment plan. Therefore, it is necessary to review the construction method in accordance with the site condition and with the future development plan of the area.

A unit price for each work item is based on AATE's previous experience regarding the existing railway Line 1, as well as several previous studies with the updated use of price escalation... The construction costs are divided into foreign portions and local portions.

1) Direct Cost

The construction costs include the following items

a) Construction machinery
b) Labor Cost
c) Material cost

2) Indirect Cost

a) Indirect cost estimated for the following:
b) Contingency : Direct cost x 15 %
c) Administration cost : Direct cost x 10%
d) Engineering : Direct cost x 10%

3) Foreign and Local Portions

The foreign portion is assumed as a CIF price, without VAT, including inland Transportation cost to site, and the local portion includes materials and machinery/equipment, with VAT.

The unit cost adopted of each working item is shown in Table 15.8-7, and the project cost by each railway project is shown in Table 15.8-8 respectively.

Table 15.8-1 Project Digest (Line 1: Stage 2)

1.Name of Project	(1) Name: Construction of extension of Line No.1 (Stage 2) (2) Phase: Short Term Project (~2010)
2.Project Location	(1) Location: Atocongo – Hospital 2 de Mayo (2) Map Link No.: Line 1 Stretch 2 (3) Project Length: 11.7 Km with 9 stations (4) Site Photo :  
3.Project Outline and its Progress	(1) Resume: Creation of North-South railway Corridor with connection to existing line. (2) Several Previous Studies: Urban railway Extension Line 1 from Atocongo until Av. Grau (2003 AATE)
4.Type of Structure	Continuous elevated track with 9 stations, Electrified, Double Track No land purchase due to the utilization of the median of the road.
5.Investment Cost	(1) Initial Investment Cost: US$ 355,400,000 1) Structure: US$ 81,400,000 2) E/M: US$ 51,100,000 3) Depot: No expense (Utilization of existing depot) 4) Rolling Stock: US$ 222,900,000 (2) Additional Investment Cost: No
6.Priority of Implementation	This project is listed in the TRANSMET Project as an urgent implementation. It is under negotiation with the Spanish Government for a loan provision.
7.Capacity and Project Life	20,000 Pax/hour at present 55,000 Pax/hour in the future. The average life of the project is 30 year of rolling stock, 40 years of structure.
8.Responsible Agencies	(1) Construction Stage: AATE (2) Operating Stage: Concessionaire, property held by municipality.
9. Financial Resources	Concession ongoing
10. Advantage of this Project	This project aims to improve present road traffic congestion between the city center and the south direction with the creation of the North-South railway corridor, especially in the district of San Juan de Miraflores and the center of city, and providing shorter travel time. Major project benefits are as follows; a. Travel Time Saving: 38 million hours/year b. CDM (CO_2) saving: 725 tons/year (US$ 5.8 million) c. Renovation of Urban Structure d. Reduction of traffic accidents e. Unemployment relief works during construction

Note: Exchange Rate: US$ 1 = Soles 3.27 (October 2004)
VAT (19%) is applied to the Local Portion.

Table 15.8-2 Project Digest (Line 1: Stage 3)

1.Name of Project	(1) Name: Extension of Line 1 (Stage 3) (2) Phase: Short Term Project (~2010)
2.Project Location	(1) Location: Hospital 2 de Mayo ~ Bayovar (2) Map Link No.: Line 1 Stretch 3 (3) Project Length: 13.00 Km with 10 stations (4) Site Photo:  
3.Project Outline and its Progress	(1) Resume: Completion of North-South railway Corridor. (2) Several Previous Studies: Preliminary Study by AATE
4.Type of Structure	Bridge on Rímac River, Electrified, Double track, Grand Level partly elevated Some part of land purchase is required at Locumba street and some other corner, and access to the depot at the Terminal Station in San Juan de Lurigancho, but the construction of the depot is planned in the Municipality owned land.
5.Investment Cost	(1) Initial Investment Cost: US$ 328,900,000 1) Structure: US$ 39,800,000 2) E/M: US$ 65,000,000 3) Depot & Rolling Stock US$ 224,100,000 (2) Additional Investment Cost: No
6.Priority of Implementation	(1) Implementing Schedule ~2010 (2) Planning Stage
7.Capacity and Project Life	20,000 Pax/hour initiate stage, 55,000 Pax/hour for the future. Average project life is 30~40 years
8.Responsible Agencies	(1) Construction Stage: AATE (2) Operating Stage: Concessionaire, but Municipality holds the property of this line.
9. Financial Resources	
10. Advantage of this Project	The purpose of this line aims to complete the creation of the North-South railway corridor and to provide economic revitalization to the railway service area. The impacts of the railway service, which connects the North-South of the city, are particularly important for the creation of a heavy mass transit system, not only for the commuter service but also for business trips.

Note: Exchange Rate: US$ 1 = Soles 3.27 (October 2004)
VAT (19%) is applied to the Local Portion.

Line 1 :
Creation of North-South Carridor

Project Name	Line 1 (33.9km)
Section	Villa El Salvador – San Juan de Lurigancho
Carriageway Number	4 Lines
Side-way Number	4 Lines
Railway Number	2 Lines

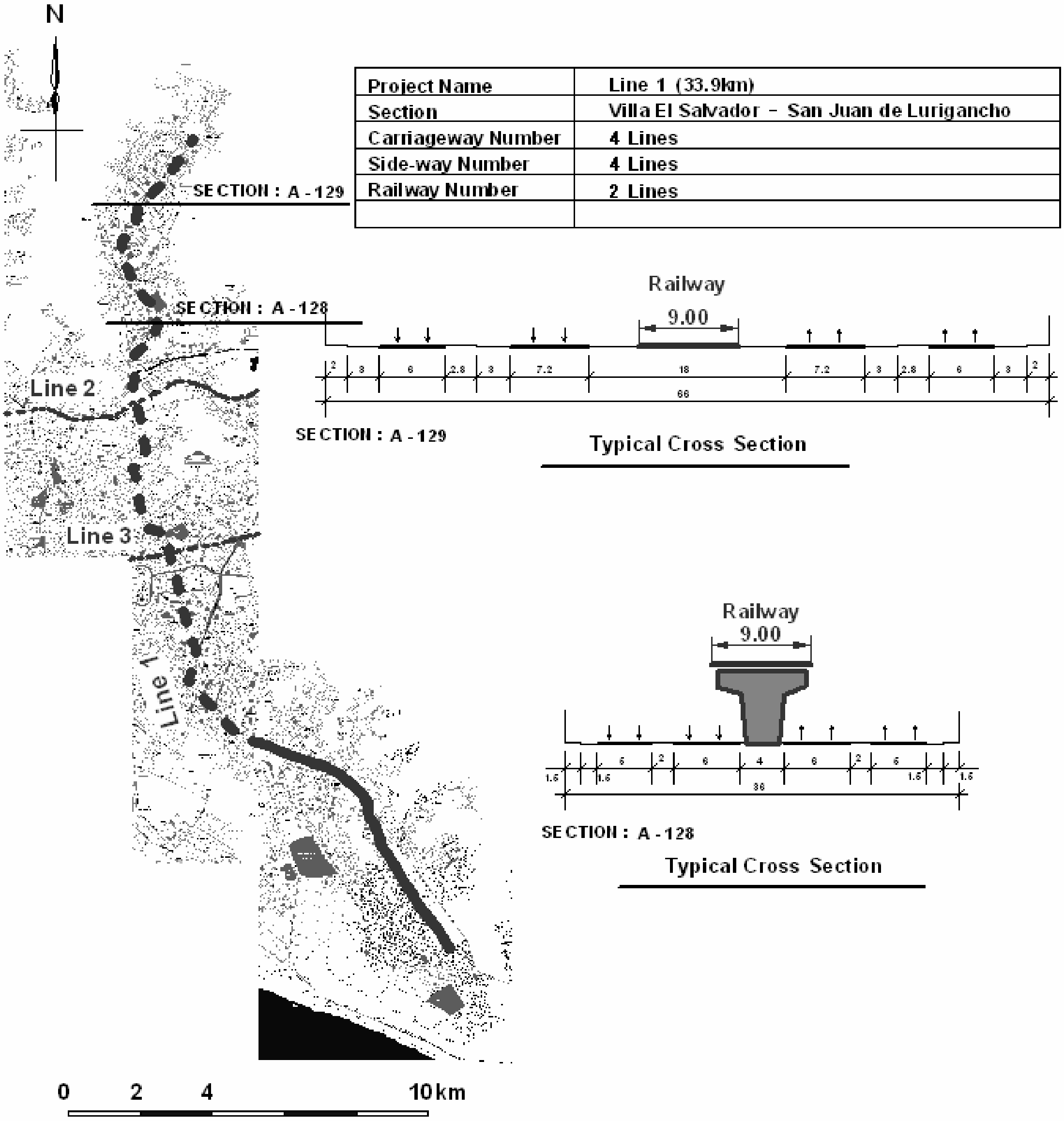


Figure 15.8-1 Location of Railway Line -1

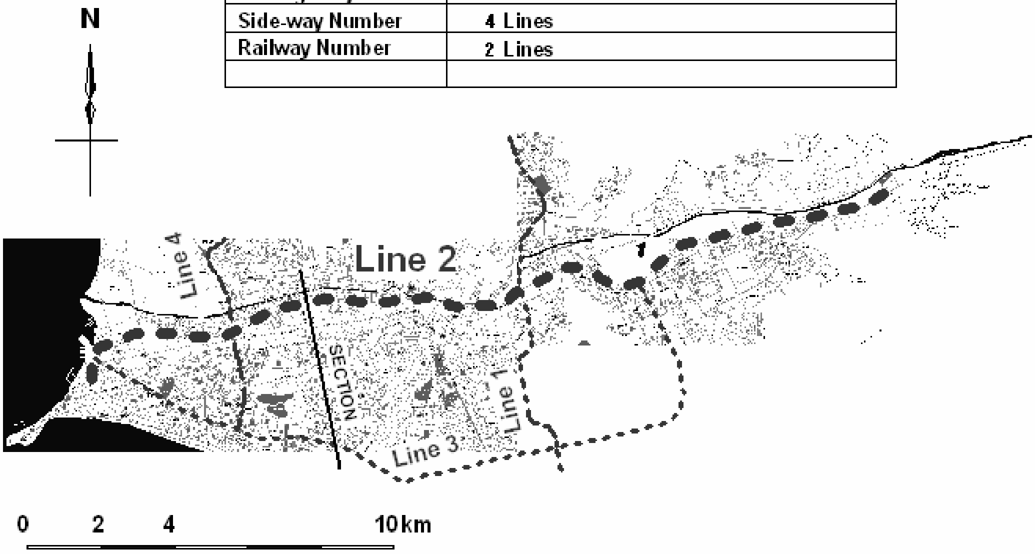
Table 15.8-3 Project Digest (Line 2)

1.Name of Project	(1) Name: Line 2 (2) Phase: Middle Term Project (~2015)
2.Project Location	(1) Location: Garibaldi – Las Torres (2) Map Link No.: Line 2 (3) Project Length: 29.0 Km with 18 stations (4) Site Photo:  
3.Project Outline and its Progress	(1) Purpose: Creation of East-West Railway Corridor (2) Feasibility study on Urban Railway Project in Lima (On going)
4.Type of Structure	At grade level, Double tracking with installation of Signaling/ Telecommunication, and Depot *(Land purchase)* : Utilization of existing Right of Way
5.Investment Cost	(1) Initial Investment Cost: US$ 660,700,000 1) Structure: US$ 72,200,000 2) E/M: US$ 123,700,000 3) Depot & Rolling Stock: US$ 464,800,000 (2) Additional Investment Cost (~2025): No
6.Priority of Implementation	Creation of East–West railway corridor is urgent, nominated by the TRANSMET project.
7.Capacity and Project Life	20,000 Pax/hour initial stage, 55,000 Pax/hour for the future. Average project life is 30~40 years
8.Responsible Agencies	(1) Construction Stage: AATE (2) Operating Stage: Concessionaire, Municipality holds the property of this line.
9. Financial Resources	Concession or other.
10. Advantage of this Project	This project aims to provide railway transport services for the East-West corridor along the Rímac River reducing heavy road traffic congestion in the morning and evening time, especially at Vitarte.

Note: Exchange Rate: US$ 1 = Soles 3.27 (October 2004)
VAT (19%) is applied to the Local Portion.

Line 2 :
Creation of East-West Carridor

Project Name	Line 2 (29.0km)
Section	Garibaidi in Callao － Las Torres
Carriageway Number	6 Lines
Side-way Number	4 Lines
Railway Number	2 Lines



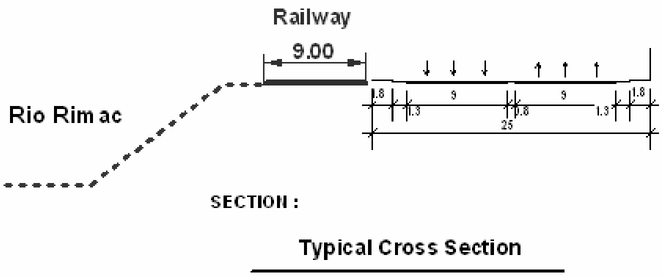


Figure 15.8-2 Location of Railway Line 2

Table 15.8-4 Project Digest (Line 3: Stage 1)

1.Name of Project	(1) Name: East-West Sub Corridor Line 3 （Stage 1） (2) Phase: Middle Term (~2020)
2.Project Location	(1) Location: Garibaldi－Javier Prado (2) Map Link No.: Line 3 Stretch 1 (3) Project Length: 16.2 Km with 14 stations (4) Site Photo:  
3.Project Outline and its Progress	(1) Purpose: This line creates part of the second East-West corridor, which connects Callao and Aviación of Line 1. (2) Several Previous Studies: Master Plan for Public Transport in Lima (2003 March)
4.Type of Structure	At grade level with grade separation at principal road cross section. Bridge type 8 locations. *(Land purchase)* : not clarified
5.Investment Cost	(1) Initial Investment Cost: US$ 260,000,000 1) Structure: US$ 45,00,000 2) E/M: US$ 95,600,000 3) Depot (reinforcement of Line2 depot) 4) Rolling Stock US$ 119,400,000 (2) Additional Investment Cost: No
6.Priority of Implementation	(1) Implementing Schedule: ~ 2010 (2) Planning Stage:
7.Capacity and Project Life	20,000 Pax/hour initial stage, 55,000 Pax/hour for the future. Average project life is 30~40 years
8.Responsible Agencies	(1) Construction Stage: AATE (2) Operating Stage: Concessionaire, Municipality holds the property of this line.
9. Financial Resources	Own Finance, Foreign Soft Loan, Concession, etc.
10. Advantage of this Project	Provision of high density of transportation service between Callao and other areas.

Note: Exchange Rate: US$ 1 = Soles 3.27 (October 2004)
VAT (19%) is applied to the Local Portion.

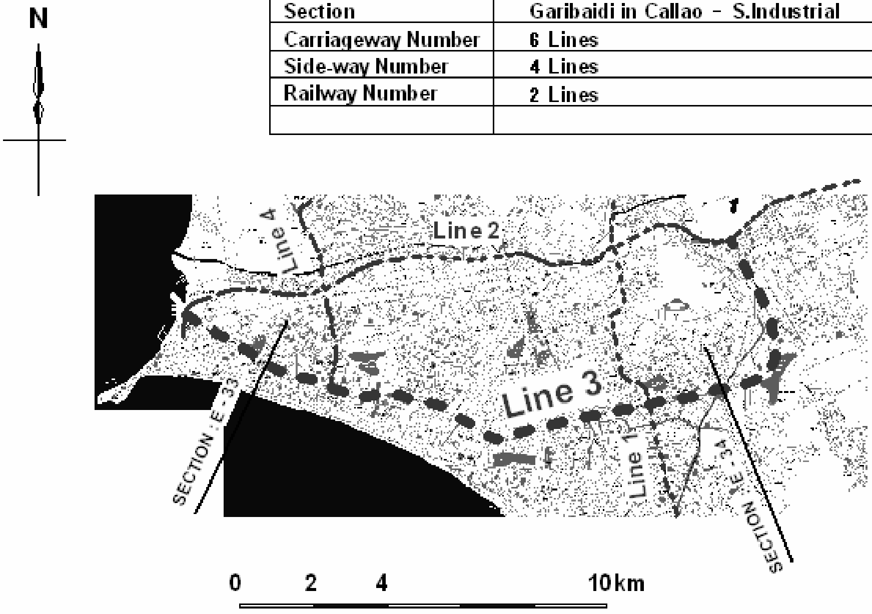
Table 15.8-5 Project Digest (Line 3: Stage 2)

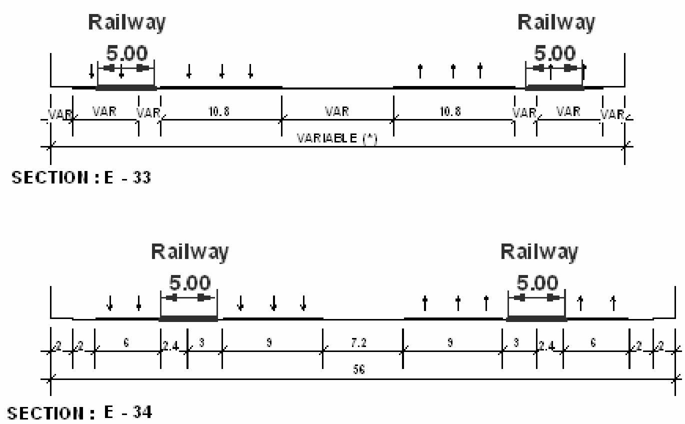
1.Name of Project	(1) Name: Line 3 （Stage 2） (2) Phase: Long Term (～2025)
2.Project Location	(1) Location: Javier Prado – S. Industrial (2) Map Link No.: Line 3 Stretch 2 (3) Project Length: 11Km 90 with 9 stations (4) Site Photo:  
3.Project Outline and its Progress	(1) Resume: The second stage of this section connects Aviación – Estación Las Torres of Line 2, aiming circular operation. (2) Several Previous Studies: Master Plan for Public Transport in Lima (2003 March)
4.Type of Structure	Grand Level with grade separation with principal road cross section. Elevated type 4 locations *(Land purchase)*: not clarified
5.Investment Cost	(1) Initial Investment Cost: US$ 230,000,000 1) Structure: US$ 27,500,000 2) E/M: US$ 70,800,000 3) Depot:& Rolling Stock: US$ 131,700,000 (2) Additional Investment Cost: No
6.Priority of Implementation	(1) Implementing Schedule: ~ 2025 (2) Planning Stage:
7.Capacity and Project Life	20,000 Pax/hour initial stage, 55,000 Pax/hour for the future. Average project life is 30~40 years
8.Responsible Agencies	(1) Construction Stage: AATE (2) Operating Stage: Concessionaire, Municipality holds the property of this line
9. Financial Resources	Own Finance, Foreign Soft Loan, Concession, etc.
10. Advantage of this Project	Semi circular operation is provided by the Second stage construction between line 1 and line2

Note: Exchange Rate: US$ 1 = Soles 3.27 (October 2004)
VAT (19%) is applied to the Local Portion.

Line 3 :
Creation of Circular Operation

Project Name	Line 2 (28.10km)
Section	Garibaidi in Callao - S.Industrial
Carriageway Number	6 Lines
Side-way Number	4 Lines
Railway Number	2 Lines





Typical Cross Section

Figure 15.8-3 Location of Railway Line 3

Table 15.8-6 Project Digest (Line 4: Stage 1)

1.Name of Project	(1) Name: Line 4 （Stage 1） (2) Phase: Long Term (~2025)
2.Project Location	(1) Location: E. Faucett – Panamericana Norte (2) Map Link No.: Line 4 Stretch 1 (3) Project Length 14Km 50 with 12 stations (4) Site Photo:  
3.Project Outline and its Progress	(1) This line 4 covers traffic flow from the North (Puente Piedra), North-East (Comas) and connects to the city center at Los Olivos. (2) Several Previous Studies: Master Plan for Public Transport in Lima (2003 March)
4.Type of Structure	Grand Level with bridge type and elevated structure with principal road Bridge type 1 location, elevated type 9 locations *(Land purchase)* : Utilization of Median of Av. Universitaria
5.Investment Cost	(1) Initial Investment Cost: US$ 189,900,000 1) Structure: US$ 37,500,000 2) E/M: US$ 85,900,000 3) Depot: Usage of Line 2 depot 4) Rolling stock US$ 66,500,000 (2) Additional Investment Cost: No
6.Priority of Implementation	(1) Implementing Schedule ~2025 (2) Planning Stage:
7.Capacity and Project Life	20,000 Pax/hour initial stage, 55,000 Pax/hour for the future. Average project life is 30~40 years
8.Responsible Agencies	(1) Construction Stage: AATE (2) Operating Stage: concessionaire, Municipality holds the property
9. Financial Resources	Own Finance, Foreign Soft Loan, Concession, etc.
10. Advantage of this Project	Incorporation of Los Olivos, San Martin de Porras and San Miguel to the Mass Transit Networks

Note: Exchange Rate: US$ 1 = Soles 3.27 (October 2004)
VAT (19%) is applied to the Local Portion.

Line 4 :
Reinforcement of theNorth Railway Corridor

Project Name	Line 2 (24.6km)
Section	San Miguel – Carabayllo in Comas
Carriageway Number	6 Lines
Side-way Number	4 Lines
Railway Number	2 Lines

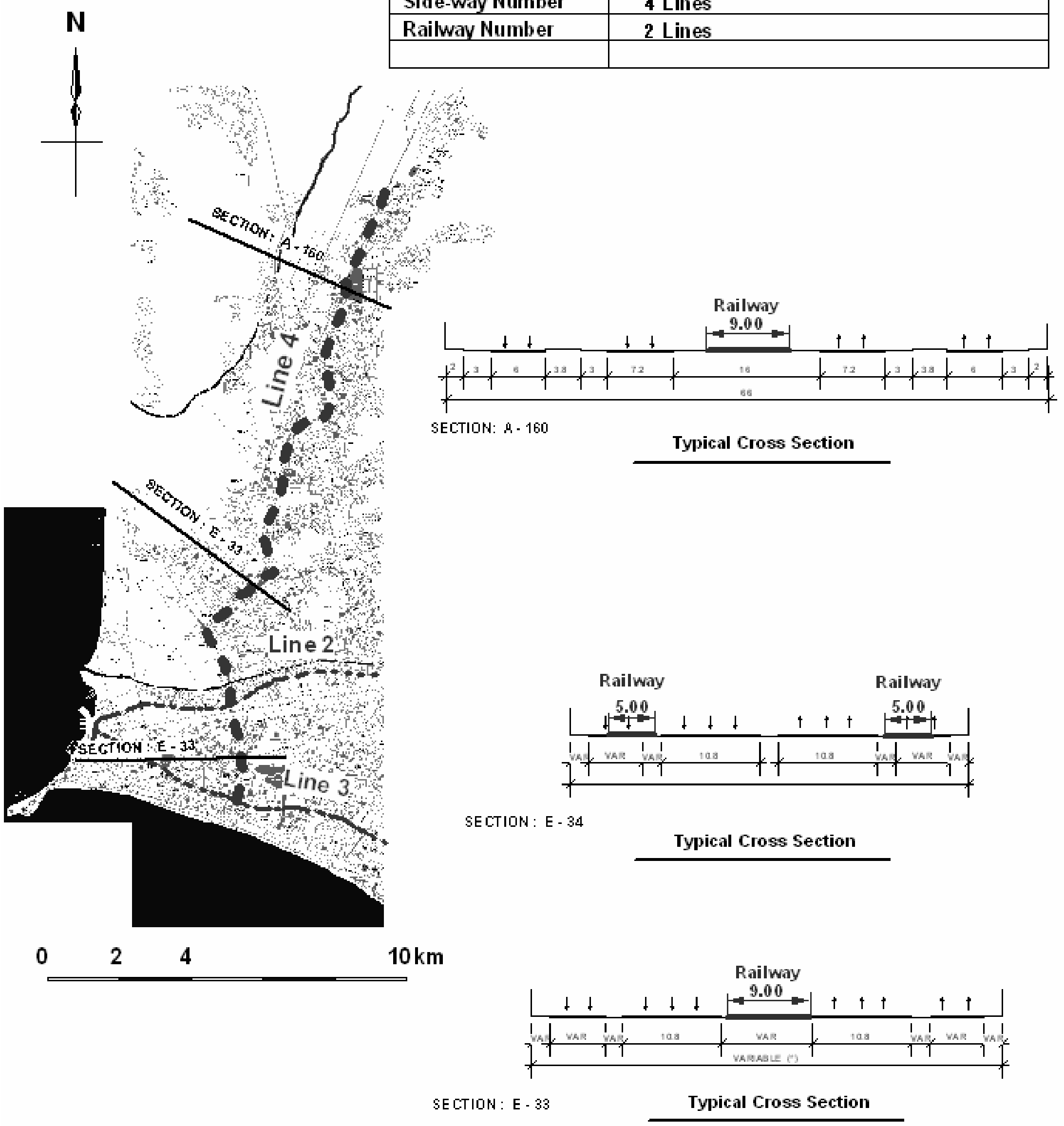


Figure 15.8-4 Location of Railway Line 4

Table 15.8-7 Unit Cost of Each Working Item

Unit Cost: 10^3 US$

Cost Item	Unit	Type of Structure	
		Ground Level	Viaduct Type
1. Cost for Civil Works (replacement, cleaning and Structure etc.)			
1) Cost: A (Includes VAT)	km	170	4,671
2) Other Expenses			
a. Contingency A x 15% } 35%	unit	26	701
b. Administration Cost A x 10% } 35%	unit	17	467
c. Engineering Fee A x 10% } 35%	unit	17	467
Total	km	230	6,305
2. Station			
1) Station Building (Includes VAT)	Station	1,008	1,440
2) Telecommunication	Station	96	96
3) Fare Collection	Station	108	108
sub total		1,211	1,643
4) Other Expenses x 35%		424	575
Total	Station	1,635	2,218
3. Track & Electric Works			
1) Track and Catenaries Works	km	1,089	1,089
2) Electric work	km	2,481	2,481
3) Signaling Work	km	726	726
sub total		4,296	4,296
4) Other Expenses x 35%		1,503	1,503
Total	km	5,799	5,799
4. Operational Control Center			
1) 0perational Control Center	Ls	4,400	4,400
2) Other Expenses x 35%		1,540	1,540
Total		5,940	5,940
5. Depot & Equipment (for 140,000m^2 of existing depot)			
1) Depot & Equipment	Ls	2,850	2,850
2) Other Expenses x 35%		998	998
Total	Ls	3,848	3,848
6. Electric Coaches (1 Set: 9 coaches)			
1) Traction Motor x 6 cars (1,645x10^3US$/car)	Coach	9,870	9,870
2) Non-Traction Motor x 3 cars (1,100*10^3US$/car)	Coach	3,300	3,300
Total *	Set	13,170	13,170

1 US$=3.27 Soles (2004 October)
VAT includes for local portion
* : assumed utilization of existing specification

Table 15.8-8 Project Cost of Each Railway Project

1. Implementation Schedule			Line 1		Line 2		Line 3		Line 4
			Stage 1	Stage 2	Stage 1	Stage 2	Stage 1	Stage 2	Stage 1
			On going	2010	2015	2015	2020	2025	2025
2. Length (km)			11.7	13	29	29	16.2	11.9	14.5
3. No. of Station			9	10	18		14	9	12
			Fixed	Av.1.3Km	(fixed by F/S)		(AV 1.2km	AV1.3km	(Av 1.2km)
4. Cost Component	Unit	UnitPric	Investment Cost		Investment Cost		Investment Cost		vestment Cos
			US$ x000	US$ x00(	US$ x00(	US$ x000	US$ x00(	US$ x00(	(US$ x000)
1) Cost of Civil Works			66,179	21,598	42,670	0	22,926	12,337	17,735
*Ground Level	km	230		2,093	6,670		3,726	2,737	3,335
*Elevated	km	6,310	66,179	12,305					
*Bridge	Place	2,400		7,200	36,000		19,200	9,600	14,400
2) Station (Building, Telecom, Signal)			15,192	18,140	29,520	0	22,140	15,012	19,817
*Ground Level	Place	1,640		11,480	29,520		22,140	15,012	19,817
*Elevated	Place	2,220	15,192	6,660					
3) Track and Electric Works			51,147	63,220	117,740	0	93,960	69,020	84,100
*Ground Level	km	5,800		40,600	117,740		93,960	69,020	84,100
*Elevated	km	5,800	51,147	22,620					
4) Operation Control Center			0	1,782	5,940	0	1,782	1,782	1,782
E&M	Ls	5,940		1,782	5,940		1,782	1,782	1,782
5) Depot &Equipment			0	1,155	3,850	0	924	0	616
*E&M	Ls	3,850		1,155	3,850		924		616
6) Rolling Stock			222,961	222,961	223,890	237,060	118,530	131,700	65,850
*9coaches formation	Set	13,170	24,482	421,440	223,890	237,060	118,530	131,700	65,850
Rolling cost is shared			222,961	222,961					
Total Cost			355,479	328,856	423,610	237,060	260,262	229,851	189,900
Cost by line			684,335		660,670		490,113		

Line 1 Stage 1: Introducing owner estimated cost

CHAPTER 16
Traffic Management Sector Plan

16. TRAFFIC MANAGEMENT SECTOR PLAN

16.1. APPROACH AND METHODOLOGY

As previously pointed out in the analysis of the current traffic control and management conditions (refer to Chapter 6), the problem of the existing traffic congestion is caused by an inadequate road capacity including the lack of a well-developed traffic management system.

An appropriate, systematic traffic management plan is essential for the safe, smooth flow of the increasing motor traffic on roads. Traffic management is particularly important to make the maximum use of the existing road facilities and to improve current road capacities. Since traffic management plans have a relatively low cost, except for those measures which improve large size facilities, and since it is possible to carry out a trial and error method while observing the effects on the traffic flow and other factors, it is necessary to introduce improvement measures that respond to the changing requirements at different times.

The traffic management plan is composed of a Short-Term Plan, and a Middle and Long-Term Plan. The short-term plan is an immediate action plan focused on issues in the selected traffic congested area, and does not comprehensively result from a study of the whole area on a unified theme, whilst the middle and long term plans are focused only on specific issues in certain areas. The approach of each plan is described below:

16.2. TRAFFIC MANAGEMENT PLAN

The traffic management plan is generally part of the short-term plan because it makes maximum use of the existing road facilities. Short-term plan objectives for promoting the quality of the urban environment are, therefore, listed as follows directly below; and measures to improve traffic control system, traffic demand management system, and traffic safety management system are proposed thereafter.

a) To achieve a smooth traffic flow;
b) To reduce traffic accidents:
c) To divert the excessive traffic demand made by private vehicles to public transport, and
d) To create “pedestrian-friendly” facilities.

The short-term plan is proposed for the next five years. It shall be followed by the implementation of the middle-term plan in the Master Plan. With a view to achieving a smooth traffic flow in the cities of Lima and Calla, the goal of this plan is to induce commuters to shift from private vehicles to public transportation, and to mitigate traffic congestion at bottlenecks. Thus, it is necessary to increase road traffic capacity through the improvement of traffic management facilities. Measures to achieve this are listed in Table 16.2-1 and these are based on current problems and issues.

Table 16.2-1 Proposed Measures for the Short-Term Plan

Current Problems	Issues	Proposed Measures
1. Traffic congestion at signalized intersections	1.Technical improvement of signal control system to manage near-saturated conditions will be necessary. 2. A capacity improvement of intersection is required 3. It is highly recommended that the traffic demand management system will be introduced, for diverting the excess traffic demand made by private vehicles to public transport.	1.Improvement of traffic signal control system. 1) Area traffic signal control system on near-saturated condition in area specified. 2) Synchronized system of traffic signal on major streets. 2. Improvement of intersection 1) Left-turn pocket plan at approach of intersection. 2) Widening plan by marking method at approach of intersection. 3. Traffic demand management system (TDM) 1) Several TDM system such as Area-Licensing/ Congestion Charging, License-Plate Numbering System, etc.
2.Blocking of signalized intersection due to heavy left-turn vehicles	1. Technical improvement of signal phasing system for left-turn traffic will be necessary.	1. Improvement of traffic signal control system. 1) Signal phasing system with green arrow for left-turn vehicles. 2. Improvement of intersection 1) Left-turn pocket plan at approach of intersection
3. Traffic congestion of buses and combis near bus stops.	1. It is recommended that effective traffic education programs should be promoted to improve driver's behavior in accordance with traffic laws and regulations. 2. Safe bus stops facilities for passengers should be considered.	1. Improvement of bus facilities. 1) Plan of bus priority signal control system. 2) Plan of Bus stop system 2. Improvement of traffic safety education system 1) Plan of driver's safety education program.
4.Traffic congestion caused by traffic spill-back from upstream.	1. Technical improvement to manage the traffic volume should be considered. 2. It is necessary to increase the capacity at bottlenecks.	1.Improvement of traffic signal control system. 1) Area traffic signal control system on near-saturated condition in area specified. 2) Synchronized system of traffic signal on major streets. 2. Improvement of intersection 1) Left-turn pocket plan at approach of intersection. 2) Widening plan by marking method at approach of intersection. 3. Traffic demand management system (TDM) 1) Several TDM system such as Area-Licensing/ Congestion Charging, License-Plate Numbering System, etc.
5. Conflict of merging and diverging, from/to side roads without signal light	1. Installation of signal lights including channelization, in order to control both motor vehicles and pedestrian traffic. 2. Curb parking at parking space in front of building along principal road should be prohibited, in order to avoid the conflict.	1. Improvement of traffic signal control system 1) Installation plan of traffic signal lights at non-signalized intersections. 2. Improvement of intersection 1) Plan of channelization system. 3. Improvement of parking control 1) Prohibition of curb parking at parking space in front of building along principal roads. 2) Installation of off-street parking space by using parking building or toll on-street parking ticket system on secondary streets.
6.Traffic accidents caused by wrong	1. Effective traffic education programs should be promoted to improve	1. Improvement of traffic safety education system.

driving manner of road users.	driver's behavior in accordance with traffic laws and regulations.	1) Plan of driver's safety education program.
7.The pedestrian involved accidents generally show a high share	1. Appropriate pedestrian safety education programs are required. 2. A capacity improvement of pedestrian facilities is required.	1. Improvement of traffic safety facilities. 1) Plan of scramble pedestrian crossing. 2) Plan of pedestrian bridge. 2. Improvement of traffic safety education system 1) Plan of pedestrian's safety education program.
8. Many black spots at signalized intersection and non-signalized intersection	1. It is necessary the monitoring system for traffic safety such as routine work system for traffic accident, human resources development for technical expert. 2. Database system for traffic accidents should be established.	1. Improvement of traffic accident monitoring system 1) Establishment of Traffic Safety Audit System. 2. Improvement of traffic safety education system 1) Plan of traffic safety campaign/seminar
9. High air pollution due to the vehicular emission	1. A technical improvement of the vehicle inspection system is highly recommended.	1. Improvement of vehicle inspection system 1) Technical improvement of vehicle inspection system.

16.2.1. PLAN DESCRIPTION

This section discusses a traffic management sector plan by introducing the improvement plan of traffic signal control systems, the improvement plan of intersections, the plan of traffic demand management systems (TDM), the improvement plan of traffic safety facilities, the improvement plan of parking control systems, the improvement plan of bus facilities (bus priority signal control system on trunk busway), the plan of traffic safety education systems, the plan of traffic accident monitoring systems (traffic safety audit system), and the improvement plan of vehicle inspection systems, in order to address the strategies and measures of the traffic management sector for the study area, presented in the previous sections.

(1) Improvement Plan of Traffic Signal Control Systems

Based on the forgoing issues, therefore, the five (5) plans listed below were proposed for mitigating traffic congestion.

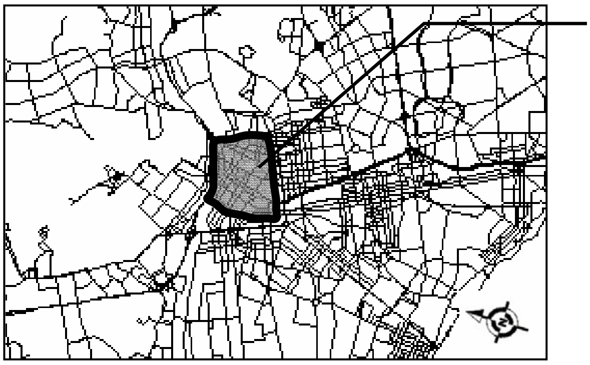
a) Area traffic signal control system on near-saturated condition in specified area;
b) Synchronized system of traffic signals on major streets;
c) Improvement plan of the signal phasing system with green arrows for left-turn vehicles;
d) Installation plan of traffic signal lights at non-signalized intersections, and
e) Plan of bus priority signal control system on the trunk busway.

1) Area Traffic Signal Control System on Near-Saturated Conditions in Specifies Area

In order to alleviate traffic congestion where there are near-saturated conditions, it is recommended to introduce one type of traffic response system. It is applicable for all traffic conditions, from under-saturation to over-saturation. As part of the advanced traffic control system of the Tokyo Metropolitan Police Department, this new signal control system* was developed. The concept of control, system configuration and the effects of application are detailed below. **Source: Advanced traffic control system of the Tokyo Metropolitan Police Department.*

a) Plan Location

As shown in Figure 16.2-1, this plan will deal with the principal road network of signalized intersections in high-road density networks of the central city, linked to key bottlenecks with near-saturated conditions following the analysis of the travel time survey. The traffic response system will be proposed for the area bordered by Av. Cajamarca, Av. Lorente, Av. Grau, Av. A Ugarte, and Av. Tacna. There are a total of 120 signalized intersections to be controlled.



Area Traffic Signal Control System covers the area of the present synchronized control area (Av. Cajamarca, Av. Lorente, Av. Grau, Av. A Ugarte, and Av. Tacna).

Figure 16.2-1 Plan Area Specified for Area Traffic Signal Control System of Traffic Lights

In determining the area for the installation of traffic signal lights for the area traffic signal control system, the following criteria were used:

- Traffic congestion sections indicating less than 10km/h of average travel speed;
- Bottlenecks that bring about spill-back condition to the downstream;
- Area of present synchronized control system controlled by Lima Municipality, and
- High-road density network of the central city, linked to key bottlenecks with near-saturated conditions.

The total signalized intersections to be controlled are as follows: 1st stage system (120 signalized intersections), 2nd stage system (additional 120 signalized intersections).

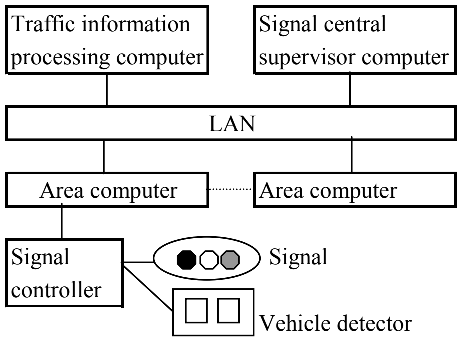
b) Concept of Real-Time Control System

The concept of control is explained below.

- When traffic demand is under-saturated, the aims of the system are not only to reduce delay and stops but also to make the traffic flow safe by moderating the speed of vehicles. It therefore uses a tool to set up an offset which corresponds to the cycle length and uses a pattern selection method for real-time offset control.
- When traffic demand is nearly saturated, this system curbs congestion by improving the efficiency of green time at critical intersections and maximizing the traffic capacity. It is provided with a critical intersection control method (Congestion alleviation control) for achieving this. The congestion alleviation control directly calculates the split and cycle length every 2.5 minutes based on the queue and the traffic volumes calculated from vehicle detector information. This system also incorporates right turn vehicle actuation, which is run every second by a signal controller at each critical intersection
- When traffic demand is over-saturated, this system runs priority control for competing traffic flows at critical intersections. If congestion has exceeded a certain limit within a specific area, such as the city center, this system controls inflow to that area. Priority control is made possible by the congestion

alleviation control function, and inflow control is provided by Intentional Priority Control.

- The system consists of sub-systems which are connected by means of an optical LAN and which share functions. As shown in Figure 16.2-2, the system consists of several Area Computers, a Traffic Information Processing Computer and a Signal Control Supervisor Computer.



Source: Advanced traffic control system of the Tokyo Metropolitan Police Department.

Figure 16.2-2 System Configuration

2) *Synchronized System of Traffic Signals on Major Streets*

a) Plan Location

Most major signalized intersections are manually controlled by traffic policemen and this manual control is not enough to keep traffic signal lights synchronized. In order to achieve a smooth traffic flow for major directions on seriously congested roads, it is highly recommended that the computerized synchronized system of traffic signal lights be improved. Figure 16.2-3 shows the plan locations for the synchronized system, which covers target routes including the key bottlenecks with near-saturated conditions. In determining the locations for installation of traffic signal lights by the synchronized system, the following criteria were used:

- Traffic congestion sections indicating less than 10km/h of average travel speed;
- Bottlenecks that bring about spill-back condition to the downstream;
- Major route to be a priority except for within the planned area for the area traffic signal control system.

Based on the foregoing considerations, target routes of the synchronized system are eleven (11) routes outside of the area traffic signal control system as follows: Av. Tupac Amaru, Av. Colonial, Av. Brasil, Av. de La Marina, Av. Arequipa, Av. Javier Prado, Av. República de Panamá, Av. Tomas Marsano, Av. Aviación, and Av. N Ayllón.

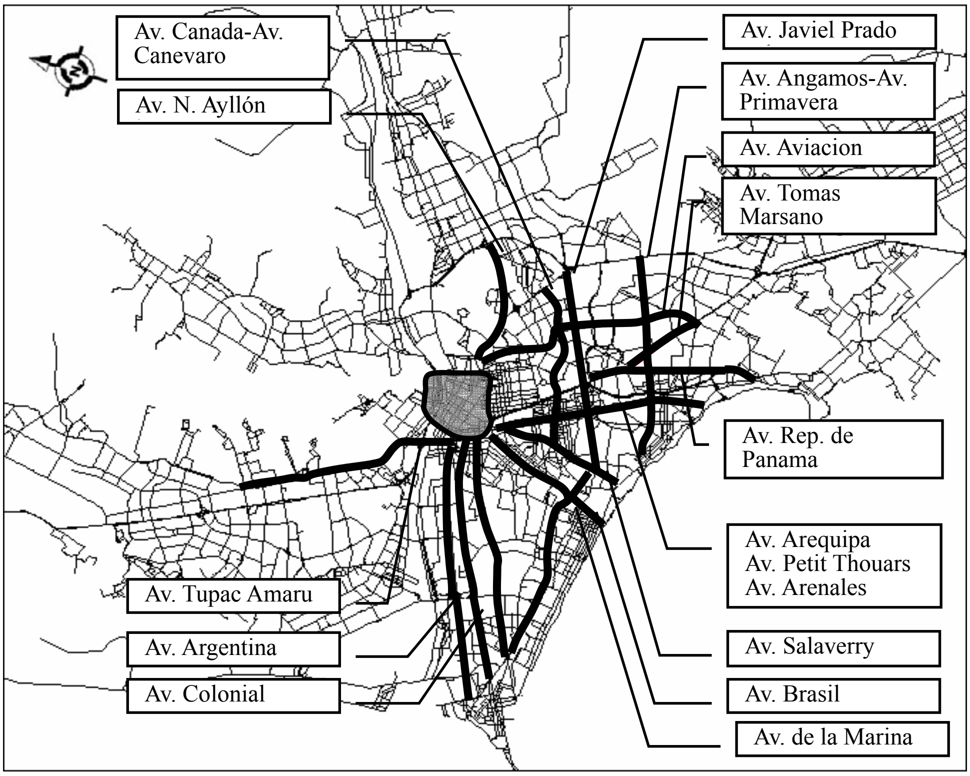


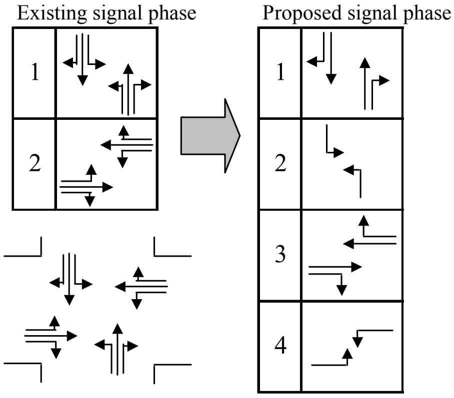
Figure 16.2-3 Plan Locations of Synchronized Traffic Control Systems

b) System Function and Control Concept

The same cycle length at neighboring intersections will enable both to operate together by setting up the offset timing. It enables vehicles to drive without stopping at the intersections in the sub areas of the synchronized traffic signal systems. The system sets a real time control by using the sensors at signal intersections, and it is controlled by the centralized system of the traffic control center.

3) Improvement Plan of the Signal Phasing System with Green Arrows for Left-Turn Vehicles

During peak periods, the blocking of intersections was quite often seen at major signalized intersections due to heavy left-turn vehicles. The existing phase system causes a spill-back to the down stream. It is, therefore, highly recommended that the two-phase system should be modified by using the method of a signal phase system with green arrows for left-turn vehicles, in accordance with the condition of traffic turning movement. Figure 16.2-4 illustrates an example of the proposed signal phase at a typical four leg intersection. In principal, the proposed signal phase is composed of four (4) phases, with the installation of a green arrow sprit for light-turn vehicles.



Proposed signal step. (cycle length=106sec)

Phase No.	Time (sec) (50 … 106)			
1	G(40)	Y	R(60)	
2	R(43)	GA	R(53)	
3	R(53)	G(40)	Y	R(10)
4	R(96)	GA		

Note: G: green, R: red, GA: green arrow (10sec),
Y: yellow (3sec)

Figure 16.2-4 Proposed Signal Phase System

4) Installation Plan of Traffic Signal Lights at Non-Signalized Intersections

The plan for the installation of traffic signal lights will deal with both the non-signalized intersections, highlighted as subject intersections for the traffic response system and the synchronized system, and the non-signalized intersections, where the volume of merging and/or diverging traffic was large. These were also highlighted as traffic bottlenecks through an analysis of the current situation, which was based on the travel time survey. The plan includes the channelization system. In determining the locations for the installation of traffic signal lights, the following criteria were used:

a) Traffic congestion sections indicating less than 10km/h of average travel speed;
b) Locations with traffic congestion due to merging and/or diverging traffic.

The installation plan will be verified based on the detailed site investigation.

5) Plan of Bus Priority Signal Control System

In order to ensuring a smooth bus operation, a bus priority signal light system should considered on the major bus routes, in accordance with the plan of the trunk busway system. The purpose of the bus priority signal control system is to realize punctual public transportation, improve the convenience for bus users, and give priority to bus transportation. In the study, as a low cost solution, the bus priority signal light system should be introduced for the trunk busway, using the method of a synchronized control system for bus priority signals and the independent traffic-actuated control system for bus priority. The concept of the bus priority signal control system is described below:

a) Plan Location

The plan of the bus priority signal control system in the study area involves the routes of the trunk bus system.

b) System Function and Control Concept

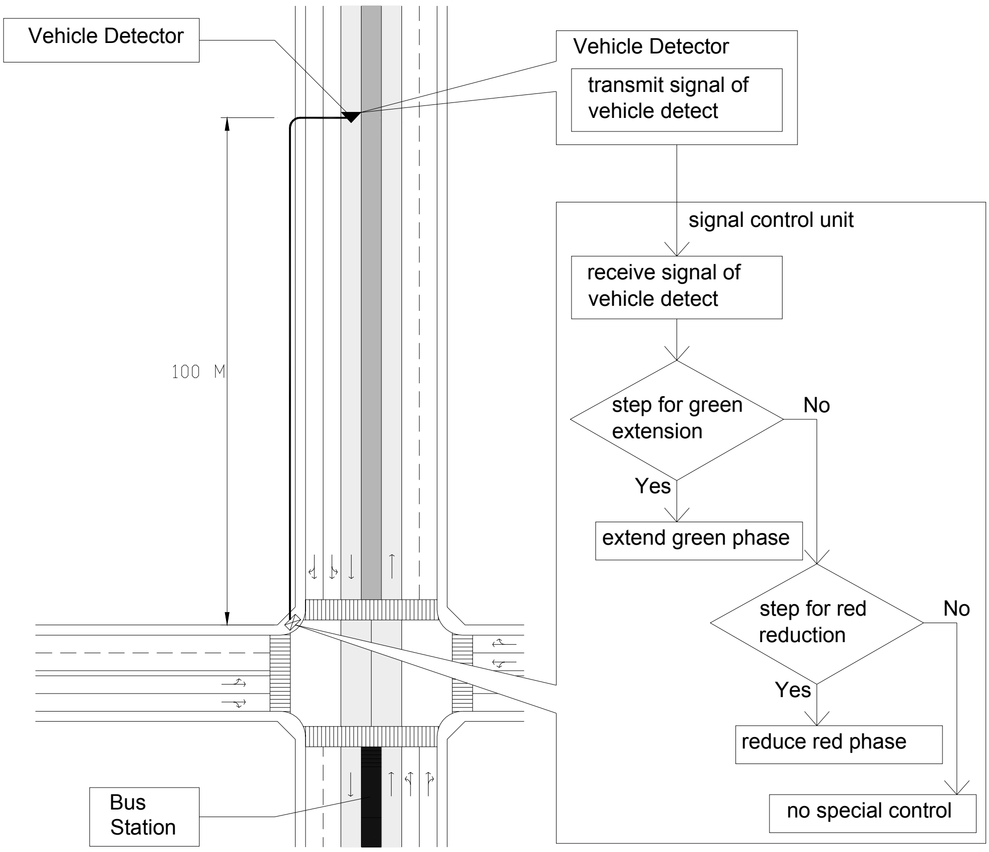
In accordance with the objectives of the bus priority traffic signal control system, the improvement of the traffic signal control system requires the following functions:

- Installation of signal lights at non-signalized intersections including bus stops on the trunk bus system: based on the calculated capacity, the signal phases and splits will be designed.
- An ultra sonic vehicle detector is installed on the segregated trunk busway, in order to detect buses, and the detector transfers bus information to the signal control unit at the local facilities. The signal control unit decides whether it

should change the timing of the signal on the basis of preset timing and received information about the bus.

- The same cycle length at neighbouring intersections will enable both to operate together by setting up the offset timing. It enables vehicle to drive without stopping at the intersection in the sub area of the synchronized traffic signal system.

Figure 16.2-5 shows a sample of the basic control method for the bus priority signal control system by introducing an independent traffic-actuated control system. When a bus passes under an ultra sonic detector at the local facility, the vehicle detector transmits the signal detection to the local controller; the signal control unit sets a step of green extension or a step of red reduction. This means that buses do not have to stop or that the waiting time is shortened at intersections as much as possible.



Source: JICA Study Team 2004

Figure 16.2-5 A Sample of the Basic Control Method for the Bus Priority Signal Control System

(2) Improvement Plan of Intersections

Based on the major problem of current traffic spill-back associated with bottlenecks caused by a lack of traffic capacity, it is necessary to increase road traffic capacity through the maximum use of the existing road facilities. The blocking of signalized intersections due to heavy left-turn vehicles is one of the causes for traffic congestion. Therefore, in the study, as a low cost solution, it is necessary to improve intersections by introducing a widening plan at the approach of the intersections with left-turn pockets in order to mitigate traffic congestion.

- Widening plan by shifting to the centerline or median, with left-turn pockets.

This plan covers the signalized intersections at the locations which, based on the analysis of the travel time and site observations, were considered to be traffic bottlenecks. In this analysis, the bottleneck point in the context of traffic engineering is defined based on the result of travel speed indicating less than 10km/h. In this section, the widening plan will be introduced. As an example, improvement plans are shown in Figure 16.2-6. The left lane of the widening plan is improved by shifting to the centerline or median, and the improvement of channeling is also required. In determining the locations for the widening plan at the approach of the intersections, the criteria used was the same as for the improvement of the traffic control system, the location to be improved is also the same as for bottlenecks.

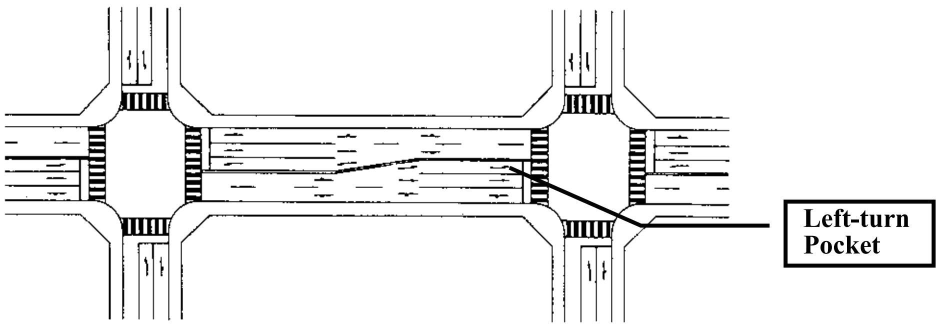


Figure 16.2-6 A Sample of the Widening Plan at Approach of Intersection

(3) Plan of Traffic Demand Management System (TDM)

Based on the analysis of the current traffic condition, it is obvious that the road and public transport projects in the study area will be insufficient to meet the future traffic volume from the viewpoint of the traffic service level. The plan must consider how to create an attractive urban environment that is amenable to road users as well as pedestrians. It is important to consider regulating the inflow of private vehicles with a public transport priority system and by increasing the use of public transport facilities. In order to maximize the investment effect of projects, a transport demand management system (TDM) will be indispensable. In this section, the plan of TDM will be recommended by introducing current implementation in other countries.

1) TDM in Major Cities in the World

Many transportation demand management techniques have been implemented in major cities of the world. This section summarizes the characteristics of major TDM techniques that may be considered for the Lima Metropolitan area as well. The measures of TDM are composed of growth management, road pricing, auto-restricted zones, parking management, fuel tax, and alternative work hours, etc. The introduction of TDM, however, is not easy because the passenger car is restricted from freedom of use, though it is estimated that several countries in Europe, Asia and U.S. have introduced or are discouraging ownership and use of private cars in the light of a better public transport service.

a) Road Pricing System

The Road Pricing System imposes charges on passenger car users passing through designated roads, in order to minimize unnecessary utilization of passenger cars and divert users to public transportation. This measure is often combined with a high occupancy vehicle lane technique.

b) High Occupancy Vehicle (HOV)

Priority lanes for high occupancy vehicles are provided and only HOV can pass the designated route without obstruction. Sometimes this system is used as a car-pooling system.

c) Area/Cordon Pricing System

This system has been adopted in Singapore and recently in London. A charge is imposed on cars to enter (i.e., "cordon pricing") or drive in (i.e., "area pricing") a designated area.

d) Parking Policy

- Park and Ride System

  Parking facilities are provided near the stations of rail-based systems, and users go from home to the stations, park their cars, and then transfer onto the rail-based systems.

- Parking Restraint Policy

  Any special method can be implemented but there are two typical methods from the viewpoint of the passenger car restraint. One is to control the construction of parking facilities to fit the policy to be introduced, and the other is to impose a surcharge fee to curb car parking in order to divert people from passenger cars to public transportation.

e) Vehicle Use Taxes

Vehicle use is restrained through user taxes imposed on fuel, tires, spare parts, etc., thus adding to the operating cost in relation to the distance traveled.

f) High Taxation

When the purchase tax is raised, car ownership is expected to be reduced. The total trips will be reduced by shifting to the public mode.

Accordingly, a variety of TDM schemes are summarized in Table 16.2-2.

Table 16.2-2 Measures of TDM Schemes

No.	Technique	Descriptions	Cities/Countries where Implemented
1.	Traffic Restrictions for Residential Areas	On-street parking controls, street closures, road humps, elimination of curbs, etc. are used to improve the residential environment	Copenhagen, Netherlands (Harlem, Delft, Enschede), Sweden (Vasteras)
2.	License-Plate Numbering System	Vehicles with odd-numbered plates are not permitted to enter controlled areas on odd-numbered working days and Vehicles with even-numbered plates are not permitted to enter on even-numbered days.	Nigeria (Lagos), Seoul, Greece (Athens)
3.	Planned Congestion	Capacity restrictions and time delays using traffic signals are applied to achieve planned congestion.	Nagoya, Nottingham, Ottawa - Carleton
4.	Traffic Cell System	Division of an urban area into zones which are only mutually accessible by public transportation or by a circuitous route. Pedestrian streets are used to prevent vehicular traffic from passing through an area.	Gothenburg, Besancon, Dijon, Nottingham, Gronigen, Delft, Geneva, Nagoya, Bremen, Ottawa
5.	Auto-Restricted Zone in CBD	Zones where automobiles are totally eliminated; a new circulation system for buses, pedestrians, taxis and delivery trucks with priority given to buses.	Boston
6.	Area-Licensing/ Congestion Charging	Vehicles are charged for entering a congested area during peak periods, excluding public and emergency vehicles.	Singapore, London
7.	Vehicles Ownership Restraints	Vehicle ownership is inhibited by high import taxes, purchase taxes, vehicle registration fees and annual licensing fees.	Hong Kong, Singapore, Seoul
8	User Taxes	Vehicle use is restrained through user taxes imposed on fuel, tires, spare parts, etc., thus adding to the operating cost in relation to the distance traveled.	Seoul
9	Cordon Toll Gates	Toll gates installed at cordons around a controlled area.	Bristol, Bergen, Oslo, Trondheim
10	Tolls placed at particular facilities to control movement	Toll gates are placed at particular facilities, like tunnels and bridges, to control movement	New York, Southampton, Seoul, Hong Kong
11	Pedestrian Streets	Selected streets are closed to vehicles to promote pedestrian use and safety and a pleasant environment	UK (London, Nottingham, Glasgow, Norwich, Liverpool, Leeds, Durham Coventry), Germany (Mainz, Munich, Stoved, Essen, Stuttgart, Cologne Dusseldorf, Hanover, Frankfurt), France (Paris, Besancon), USA (Boston, Minneapolis, Madison, Minnesota, California), Netherlands (Hague, Gronigen), Copenhagen, Brussels, Ottawa, Tokyo, Rome, Geneva, Vienna, Gothenburge.
12	Pedestrian/Bus Street	Pedestrians and buses share road space to reduce traffic congestion and to promote a pleasant environment.	Germany (Trier), UK (Derby, London, Leeds)

Source: H.C. Park, 'Traffic Demand Management: Some Possible Techniques for Bangkok,' Master's Thesis, Asian Institute of Technology (AIT), 1989, adapted.

2) Measures of TDM in the Study Area

The major measures of TDM are classified into3 categories: to discourage car ownership, to discourage car use and to alleviate peak-periods demand. These measures have to be introduced under conditions where the public transport is served at a level that makes it possible to shift the car owners to public transport. This is a difficult task because car owners in Lima have very strong propensity to use a car, i.e., they will use a car whenever and whenever available. Accordingly, in this section, it is, highly, recommended that the following TDM measures should be introduced in accordance with the strategic scheme of public transport system.

a) Introducing a high taxation system;
b) Introducing a car use tax system
c) Introducing an area licensing system, and
d) Introducing a license-plate numbering System.

(4) Improvement Plan of Traffic Safety Facilities

The traffic safety facilities are not sufficient in number, such as pedestrian bridges and safety guard devices. The pedestrian behavior in the study area is seen as lawless in some cases and well behaved in others. For instance, they cross the streets ignoring signal lights, and wander into vehicle lanes to shortcut their journey. Pedestrians are generally low priority. It is observed that drivers generally pay little attention to pedestrians even when the pedestrians are using pedestrian crossings at intersections. This attitude must change, with pedestrian traffic considered as important as vehicular traffic through the provision of safe and convenient facilities and the according of sufficient priority to pedestrians on roads, including pedestrian education through road safety campaigns. This section, in particular, discusses safety facilities for pedestrians in order to prevent traffic accidents involving pedestrians, the objectives of the development of pedestrian facilities in the study area are:

a) To prevent "jay-walking" of pedestrians;
b) To ensure a safe pedestrian environment, and
c) To create "pedestrian-friendly" facilities.

Based on forgoing current problems and consideration, it is highly recommended that the following two (2) plans be proposed for pedestrian safety.

a) Plan of pedestrian crossing bridge, and
b) Plan of scramble pedestrian crossing at signalized intersection.

1) Plan of Pedestrian Bridge

The plan of a pedestrian bridge in the central city will be proposed in order to prevent traffic accidents involving pedestrians. The following locations are considered to require pedestrian bridges.

a) Locations where both motor and pedestrian traffic intermingle to a high degree;
b) Areas with a high incidents of vehicle-pedestrian accidents, and
c) Dual way roads with more than 6 lanes without safety zones to allow pedestrians to stand safely.

2) Plan of Scramble Pedestrian Crossing at Signalized Intersections

At principal road intersections with large volumes of pedestrians, where there are conflicts between pedestrians and right-turning traffic, this leads to traffic accidents involving pedestrians. In order to reduce crossing times for pedestrians, by minimizing the carriageway crossing distance, and contributing to pedestrian safety, it is recommended that scramble pedestrian crossings should be installed at signalized intersections with high volumes of pedestrians crossing.

a) Scramble Control of Signal Light

There are two types of scramble pedestrian crossings such as part-time operation and whole day operation. A scramble control can be used for an intersection with many pedestrians. An exclusive pedestrian phase is incorporated; it is equivalent to the all-red situation for vehicular traffic. In determining the calculation of the cycle length and the saturation ratio, the time required for the exclusive pedestrian phase is regarded as lost time. The duration of the exclusive pedestrian phase is determined from the physical dimensions of the size of the intersection and expressed as the time required to cross the intersection. Since this is a signal control system giving priority to pedestrians crossing, the vehicular capacity at the intersections will be decreased. Therefore, the implementation of scramble control must be adjusted for the situation of traffic congestion. An example of a layout and a scramble phase is shown in Figure 16.2-7.

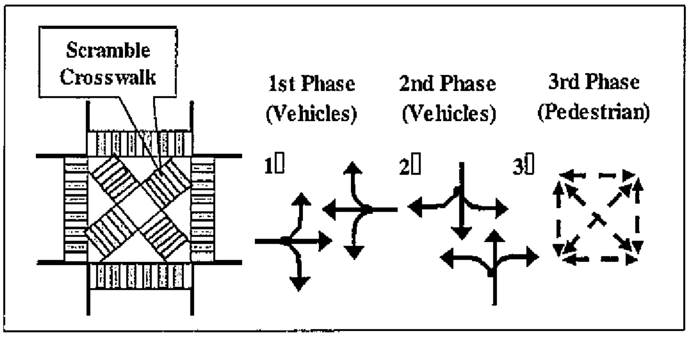


Figure 16.2-7 Layout of a Scramble Phase

(5) Improvement Plan of the Parking Control System

Curb parking is prohibited on most of the major roads in the study area. Currently, the parking conditions are not a serious problem due to the preparation of off-parking facilities. There, however, there are many parked cars at off-street parking lots along the streets in front of buildings. During peak periods, the conflict of merging and diverging, from/to parking lots along the streets is observed in the study area. It leads to set the start of traffic congestion. It is, therefore, recommended that the parking system should be improved by introducing a parking control system. Two kinds of parking measures may be recommended; one is to take away the parking lots along the principal roads and the other is to install the charged on-street parking lots on the minor streets, by introducing a parking ticket system. These two ought to be applied at the same time within one system. The concept of the parking control system is shown in Figure 16.2-8.

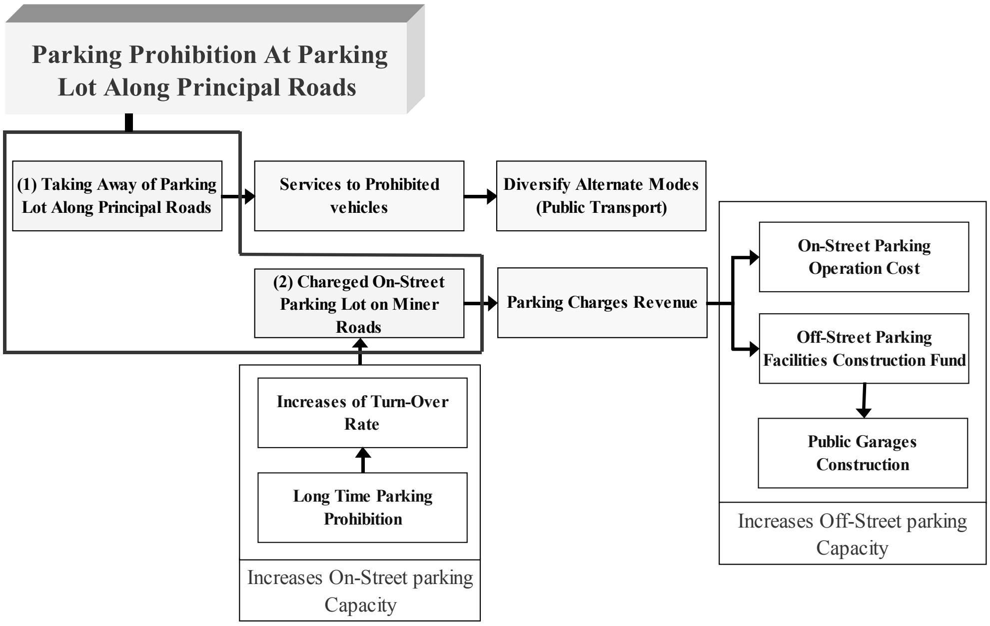


Figure 16.2-8 Concept of Parking Control System

a) Parking Prohibition at Parking Lots along Principal Roads

The locations for the parking prohibition at parking lots along the principal roads should be designated based on the detailed site investigation.

b) Installation of Charged On-Street Parking Lots on Minor Roads

Under the recommended system every vehicle parked on a designated street must pay a certain amount of parking charge and cannot park continuously longer than three (3) hours at one time, even by paying more. The main purposes of this are:

- To raise the turnover rate in order to increase the parking capacity in the planned miner streets;
- To exclude long-stay vehicles, for instance vehicles that park throughout working time, in order to provide more opportunities to vehicles to park for shopping or business.
- To promote the conversion from private mode to public mode, and
- To increase funds to develop off-street parking facilities.

<u>Control Method</u>

The installation of automatic parking ticket vending machines is the most common way to enforce parking time control. It, however, requires a considerable initial and maintenance cost compared to the parking charge collected. Figure 16.2-9 shows an automatic parking ticket vending machine on a street in Japan. In an area where these machines are installed, the parking lot is marked on the roadside in the same way as a common on-street parking lot. Parking at these lots is charged from 08:00 until 20:00 hours. A driver may buy a ticket from the machine and he/she puts it on the vehicle dashboard.

It is, however, recommended to adopt a parking ticket system, in this case, which is economic and does not use a machine or instrument. A driver needs to buy a ticket from an inspector. When parking on the designated street, he/she has to put it on the dashboard where it can be seen from the outside. An inspector shall be responsible for the sale of tickets, and for patrolling to check for violators, the inspector shall stick a traffic violation ticket on the car to inform the driver of his/her offence. The outline of the parking ticket system is shown in Figure 16.2-10.

Figure 16.2-9 Parking Ticket Machine

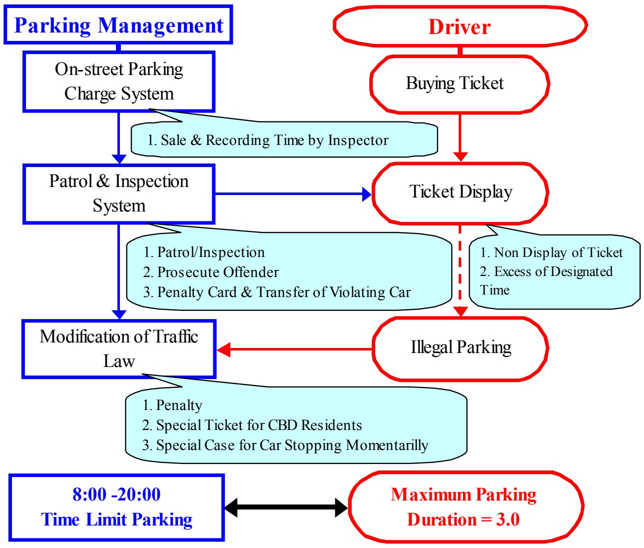


Figure 16.2-10 Outline of Parking Ticket System

(6) Improvement Plan of Bus Facilities (Bus Priority Signal Control System on Trunk Busways)

This section refers to the previous description of the improvement plan of the traffic signal control system.

(7) Plan of the Traffic Safety Education System

This section discusses the measures for securing the safety of road traffic in the study area. The major issues of traffic congestion in the study area are mainly caused by the gap between traffic demand and traffic capacity. It is, however, necessary that drivers/pedestrians obey traffic signals/regulations and understand the merit to traffic safety. In order to promote the use of public transport, it is necessary to attain traffic safety for pedestrians and safety driving of combi/bus owners/drivers. The conflicts between vehicular traffic and pedestrians, which reduce the efficiency of the urban street network, can be minimized by improving the road/traffic facilities and implementing traffic safety measures including effective driver/pedestrian education programs. Such measures and programs, if successfully implemented, will not only improve traffic flows, but also the safety, convenience, and comfort of both pedestrians and drivers.

Generally, countermeasures against traffic accidents are composed of 3 "E"s: Education, Engineering and Enforcement. In this section, especially, the plan of traffic safety education system focuses on traffic safety education for drivers, pedestrians and traffic trainers by introducing the implementation of workshops and campaign propaganda.

1) Objectives

The objective is to implement a pilot traffic safety program by introducing the implementation of workshops and campaign propaganda. The objectives of the driver/pedestrian traffic safety education programs and campaigns are to attain the following improvements by target groups, such as the general public, drivers, traffic trainers, and traffic control/management groups.

a) Prevention of traffic accidents and improvement of driving manners for the general public;

b) Improvement of driver's compliance with traffic laws and regulations;
c) Improvement of driver's education system in driving schools for traffic trainers, and
d) Effective traffic enforcement and training of traffic trainers for traffic control/management groups.

2) Methodology

Programs of traffic safety education are comprised of the following 5 parts.

a) Preparation of educational materials;
b) Preparation of a practical demonstration team for the traffic safety education program and campaign;
c) Training education by workshop system, and
d) Execution of a traffic safety campaign.

3) Plan Description

a) Action Plan of Workshop

In order to improve driving manner, driver's compliance with traffic laws and regulations, it is recommend that the action plan of a workshop be done at fixed intervals. The major scope is proposed as follows: 1) organization of the lecturer as to how the lecture assignment will be prepared, 2) workshop will be scheduled, 3) education materials of texts, video films and lecture materials will be prepared, 4) workshop and impact study of participants in the workshop, (before/after) will be implemented.

b) Action Plan of Campaign Propaganda

In order to enlighten the driving manner, driver's compliance with traffic laws and regulations, the campaign propaganda should be done periodically by using methods of mass media and pamphlets/stickers with major slogans on the street. The major scope is proposed as follows: 1) propaganda by mass media, such as TV spots, Newspaper and Radio, will be executed, 2) on-street campaigns, with the participation of schools, will be executed at the corner of the signalized intersections, school students will distribute stickers and pamphlets to pedestrians and drivers, 3) stickers, banners, and pamphlets that outline the traffic safety campaign will be prepared, as well as t-shirts for students.

(8) Plan of Traffic Accident Monitoring System (Traffic Safety Audit System)

In order to monitor the traffic accidents by using a routine work, the traffic safety audit system (TSAS) should be established in the study area. The TSAS is comprised of five (5) functions as follows: 1) Investigation and database system, 2) Analysis on hazardous locations and confirmation of problems, 3) Planning of measures, 4) Implementation of countermeasures, and 5) Follow-up system. In this section, the plan of the traffic safety audit system will be discussed as follow:

1) System Function of the TSAS

In accordance with the objectives, the traffic safety audit system requires the following five (5) functions (see Figure 16.2-11):

a) Investigation and database system

The task is to collect the basic information for analysis of traffic accidents. As pointed out in the previous analysis of information of traffic accidents in the study area, the data base system in statistics was not suitable. In order to predict the causes of accidents, the accident record-format of traffic accident should be improved. The key tasks are, 1) study of accident statistics and 2) collection of information from drivers and residents.

b) Analysis on hazardous locations and confirmation of problems

The task is to analyze accidents based on the pervious process. The key tasks are, 1) examination of accident records, 2) collection of relevant materials, 3) execution of field investigation, execution of accident pattern of frequent occurrence, and 4) presumption of accident causes.

c) Planning of measures

The task is to plan measures based on the results of the accidents analysis. The key tasks are, 1) selection of measures corresponding to presumed causes, 2) examination of applicability of measures, 3) clarification of effects and side effects of measures, and 4) examination of the combination of measures.

d) Implementation of countermeasures

The task is to implement the proposed measures. The key tasks are, 1) cost estimation of countermeasures, examination of budget (finance), 2) consultation with concerned agencies, 3) explanation to residents, 4) decision on sequence of implementation, and 5) implementation.

e) Follow-up system

The task is to follow up the measures implemented. The key tasks are, 1) measurement of effects of countermeasures, 2) comparison of before/after surveys, and 3) execution of campaign and enforcement.

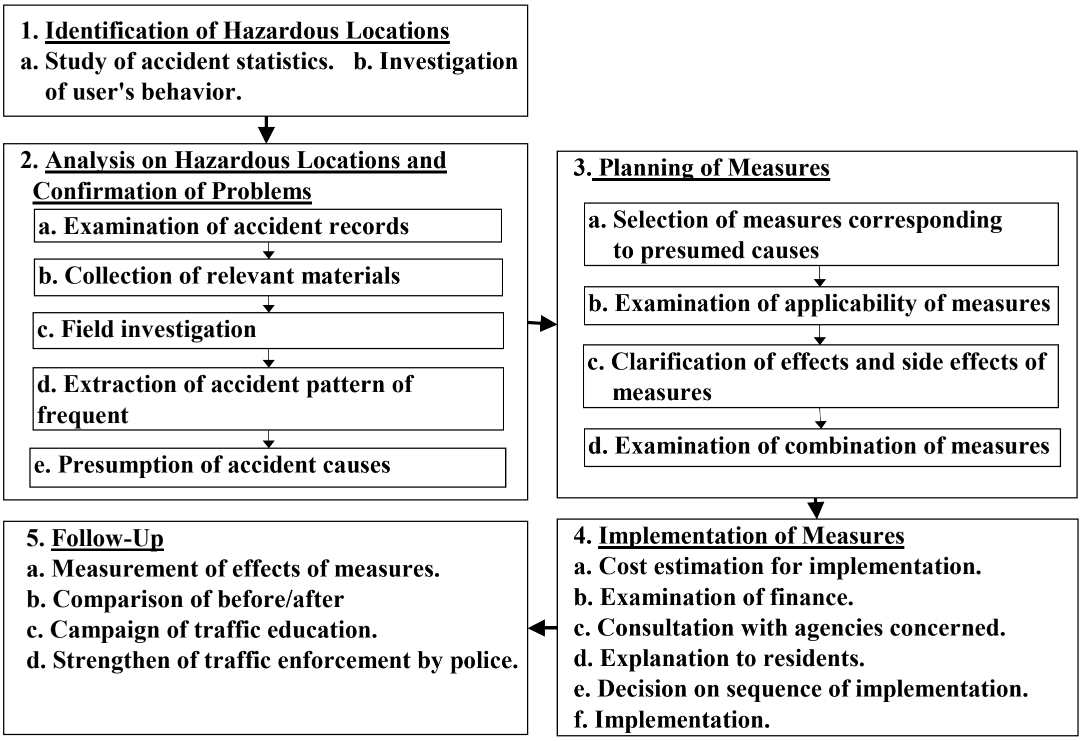


Figure 16.2-11 Procedure of Key Works for the TSAS

(9) Improvement Plan of the Vehicle Inspection System

The air pollution caused by vehicular emissions should be improved by a suitable vehicle inspection system. Currently, the vehicle inspection system is not full adopted, however, in this year, the inspection procedure could be licensed to private companies under the complete responsibility of the government. In order to implement a more stringent vehicle inspection system, it is the best way that the inspection procedure can be licensed to private companies. A technical improvement of the vehicle inspection system is highly recommended. A proposed vehicle inspection system will consider the following two steps (see Figure 16.2-12):

a) Applicants could prepare for the inspection by having their car updated for inspection by a private garage. This, however, is not mandatory but will ensure that the car is prepared to maximize the chances of passing the more rigorous inspection system.

b) It is necessary to regulate the car inspection system by law. Offenders, those failing to provide a regular inspection certificate, should be penalized with the suspension of the vehicle's license until a regular and updated vehicle inspection certificate can be shown. This system revolution is possible but requires an administrative decision and a will to change.

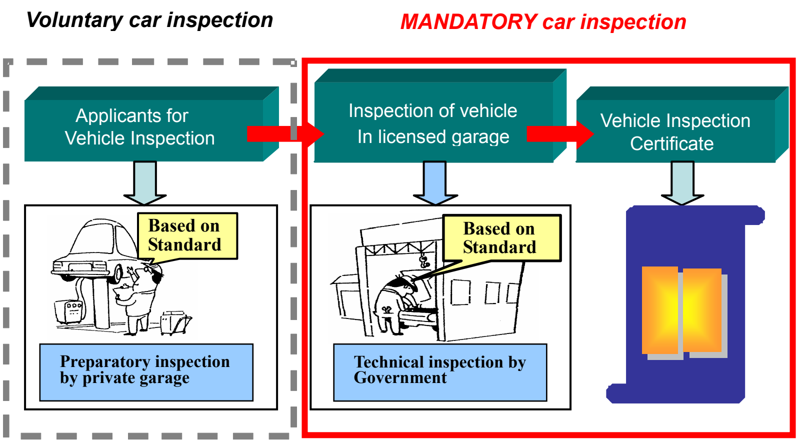


Figure 16.2-12 Proposed Vehicle Inspection System

Regarding the technical inspection items, effective standard for technical inspection item should be adopted. A proposed standard inspection item is comprised of 1) Part I: Chassis, 2) part II: Body, 3) Part III: Lamp.

Table 16.2-3 Proposed Inspection Items

Part		Items	No. of Sub-	Truck, Tractor	Bus	Motor Vehicle
I. Chassis	1	Frame	3	●	●	-
	2	Bumper	3	●	●	●
	3	Turning control system	4	●	●	-
	4	Disc wheel	1	●	●	-
	5	Tires	2	●	●	●
	6	Axle	1	●	●	-
	7	Spring	1	●	●	-
	8	Shock absorber	2	●	●	-
	9	Mud flap	6	●	●	-
	10	Hand brake	2	●	●	●
	11	Parking brake	6	●	●	●
	12	Engine	3	●	●	●
	13	Exhaust system	5	●	●	●
	14	Drive train system	3	●	●	-
	15	Ignition system	1	●	●	-
	16	Electric system	6	●	●	●
	17	Horn	6	●	●	●
	18	Fuel tank	4	●	●	-
	19	Speedometer	3	●	●	●
	20	Tachometer	3	●	●	-

Part		Items	No.	Truck, Tractor	Bus	Motor Vehicle
II. Body	1	Windshield and glass	4	●	●	-
	2	Rear view mirror	2	●	●	●
	3	Wiper	4	●	●	●
	4	Sun visor	1	-	-	●
	5	Rear body	4	●	-	-
	6	Letter, Picture or any mark	7	●	●	-
	7	Body color	1	●	●	-
	8	Roof	2	-	●	-
	9	Floor	2	-	●	-
	10	Side window	7	-	●	-
	11	Entrance door	8	-	●	-
	12	Emergency door	7	-	●	-
	13	Driver seat	3	-	●	-
	14	Passenger seat	2	-	●	-
	15	Driver cab	3	●	-	-
	16	Driver partition	2	-	●	-
	17	Passenger grip	4	-	●	-
	18	Bell for stop signal	2	-	●	-
	19	Fluorescent pad	13	●	●	●
	20	Safety belt	1	●	●	●

Part		Items	No.	Truck, Tractor	Bus	Motor Vehicle
III. Lamp	1	High beam lamp	7	●	●	●
	2	Low beam lamp	5	●	●	●
	3	Lamp for vehicle width	7	●	●	●
	4	Turning lamp	8	●	●	●
	5	Tail lamp	5	●	●	●
	6	Stop lamp	6	●	●	●
	7	Reversing lamp	6	●	●	●
	8	License plate lamp	6	●	●	●
	9	Lamp for vehicle's height and categories (for vehicles whose height exceeds 2.5m)	12	●	●	-
	10	Inside vehicle lamp	5	●	●	●
	11	Lamp for route plate	2	-	●	-
	12	Side lamp (option)	10	●	●	●
	13	Side turn lamp (option)	5	●	●	●
	14	Fog lamp (option)	7	●	●	●
	15	High mount stop lamp (option)	9	●	●	●
	16	Other lamps	1	●	●	●

Table 16.2-4 Sample of Format Sheet for Technical Inspection Items

Part	Items		How to check	Truck, Tractor	Bus	Motor Vehicle
III. Lamp	1	High beam lamp	1. White or light yellow	●	●	●
			2. 2 units	●	●	●
			3. Fixed at the front in the same level, both left & right	●	●	●
			4. Both of them must be the same color	●	●	●
			5. Fixed higher than the ground at least 40cm but not exceeding 1.35m	●	●	●
			6. They will be lightened whenever tail lamps are lightened except in case of temporary signal	●	●	●
			7. Additional 2 units are allowed (option)	●	●	●
	2	Low beam lamp	1. White or light yellow same as high beam lamp	●	●	●
			2. 2 units	●	●	●
			3. Fixed at the front in the same level, both left & right			
			4. Fixed higher than the ground 40cm but not exceeding 1.35m. And the length from the edge must not exceed 40 cm.	●	●	●
			5. They will be lightened whenever tail lamps are	●	●	●

16.3. MIDDLE AND LONG-TERM PLAN

The middle and long-term plan is proposed for the next ten/twenty years. It shall be followed by the implementation of the other sector's middle/long-term plan in the Master Plan. The objective of this plan is to induce commuters to shift from private vehicles to public transportation, and to mitigate traffic congestion at bottlenecks. Measures to achieve this are listed in Table 16.3-1 and these are based on future problems and issues.

Table 16.3-1 Proposed Measures for the Middle and Long-Term Plan

Future Problems	Issues	Proposed Measures
1. Traffic congestion at signalized intersections.	1. Technical improvement of the traffic flow control system to manage saturated conditions will be necessary. 2. It is highly recommended that traffic/road information, such as traffic situations and the location, cause and result of incidents also be offered to drivers for safe and pleasant driving.	1. Introduction of area traffic control system. 1) Expanding system of area traffic signal control system on saturated condition. 1. Introduction of traffic/road information system. 1) Information collection system 2) Data processing system 3) Information supply system
2. Promotion of a service level of bus transportation.	1. Technical improvement of bus priority control system will be necessary. 2. It is recommended that a passenger-friendly system be introduced.	1. Bus location information system. 2. Bus priority signal control system on normal roads.

16.3.1. AREA TRAFFIC CONTROL SYSTEM AND TRAFFIC/ROAD INFORMATION SYSTEM

The medium and long-term plans related to traffic management are focused on the traffic information system and area traffic control system from a medium and long-term perspective; the new system uses vehicles detectors which enable the automatic and real-time collection of traffic information supplied to drivers through message sign boards. The area traffic control system is the expanding system of the traffic response system.

(1) Concept of the Plan

The traffic information system with area traffic control system should be installed stepwise, because the existing traffic signal control system must also continue to function. The system expansion should be done as follows:

a) Renewal for the functional upgrading of various traffic control installations of the control center and the local facilities of signal lights and traffic detectors.
b) Expansion of the traffic control area providing traffic signals at new intersections.
c) CCTV cameras should be installed at effective points, such as susceptible traffic congestion locations, in order to expand traffic surveillance and to improve traffic control.
d) Expansion of the linear traffic-actuated control for each sub-area of the existing route.
e) Expansion of an area traffic control through the interconnection of sub-areas around the city center.
f) Improvement and expansion to achieve an advanced system which can control traffic quickly and in a timely manner, in response to real changes.

(2) System Configuration

The system configuration is comprised of an information collection system, a data processing system and an information supply system. Each basic function is shown in Figure 16.3-1.

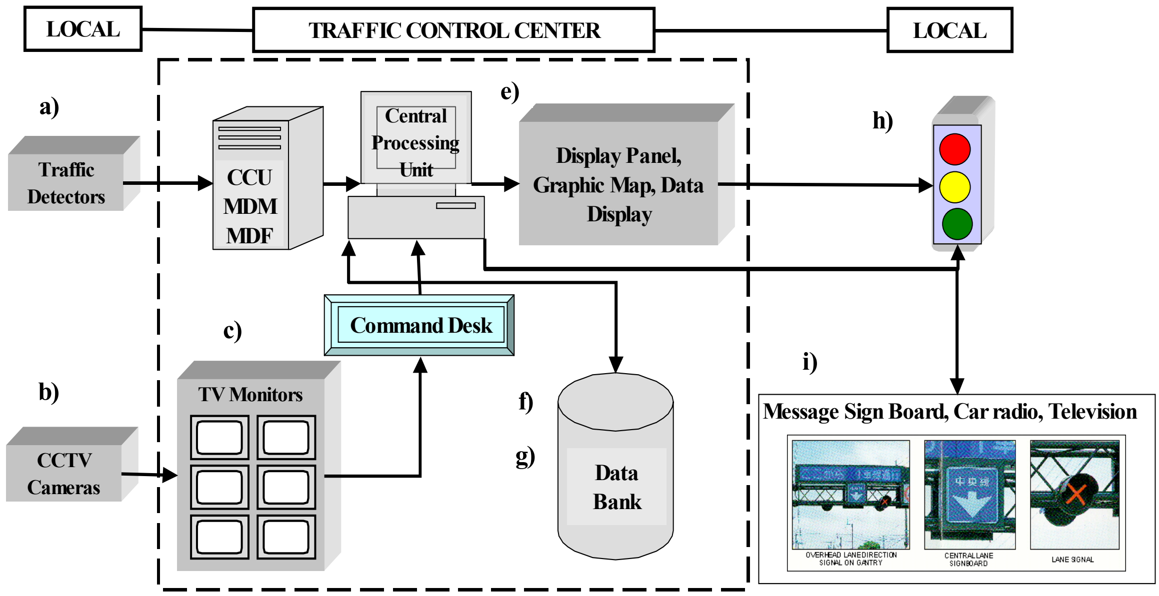


Figure 16.3-1 System Configuration for Traffic Information System with Area Traffic Control

1) System of Information Collection at Local Facilities

a) Automatic collection of traffic data using roadside vehicle detectors

The traffic detectors will be installed at the entrance of major intersections and road sections of uninterrupted flow, which are required for traffic control. The data observed by the detectors at these points will be sent to the control center in real time. The observed traffic data includes traffic volume, length of traffic queue, occupancy rate, traveling speed etc. and they should be selected and decided according to the adopted traffic control policy, because such data will be used in traffic analysis and planning as well as for signal control.

b) CCTV camera installed at roadside

2) Data Processing System at Traffic Control Center

a) Monitoring of traffic conditions by means of CCTV cameras

The CCTV cameras (Closed Circuit Television System Camera) will be installed at the points where observation is necessary at all times, such as chronically congested intersections, merging or diverging points and places where traffic accidents often occur. The surveillance system of road conditions and traffic situations in the control center (at all times) is very important in traffic control. The monitors that systematically observe the information from the TV cameras, by route, will be provided in the control center, strengthening the surveillance system. The surveillance of various situations, such as road conditions and accident conditions in real time at the control center, will facilitate the necessary counter-actions, and will enable appropriate instructions to be given for such congestion and accidents.

b) Aggregation of collected traffic data for calculation of signal parameters, such as controlling the intervals of signals (red/green) in proportion to traffic volume

In the Central Processing Unit, information on traffic flows monitored by the traffic detectors will be collected and processed, and the parameters of signal control will be set. In addition, the control of exchange and monitoring of traffic information will be carried out with the sub-center.

c) Display of traffic congestion and traffic incidents on the Central Graphic Panel Display Board

In the display panels, several data will be monitored, providing information for decisions on traffic flow control for the traffic controller at the command desk.

d) Accumulation of traffic data in a data bank & collection of basic data for traffic control operations

The detected data for traffic control, such as traffic flow data, will be collected and processed by route, by areas and by time zones etc. as a database, which should be updated periodically. The database will be utilized for the analysis and improvement of various traffic technologies as well as for setting the parameters of signal control.

3) Information Supply System at Local Facilities

a) Control of signal lights

The traffic signal lights will be operated based on the parameters of signal control from the Central Processing Unit (CPU).

b) Supply of necessary traffic information to users

Traffic information, such as the traffic situation and the location, cause and result of the incident, will be also offered to drivers for a safe and pleasant drive. In particular, the quick delivery of information on unusual traffic phenomena will contribute to reducing secondary traffic incidents such as accidents and traffic congestion. Appropriate instruction and regulation to drivers on the unusual phenomena can be made through analyzing the correct situation with visual information from the CCTV camera and data.

(3) System Configuration

It is proposed to install a system to supply information on road and traffic conditions, necessary for drivers, through a resident traffic manager, in addition to the traffic control system to control traffic signal lights. Figure 16.3-2 shows the relationship between the traffic signal control system and the traffic information system.

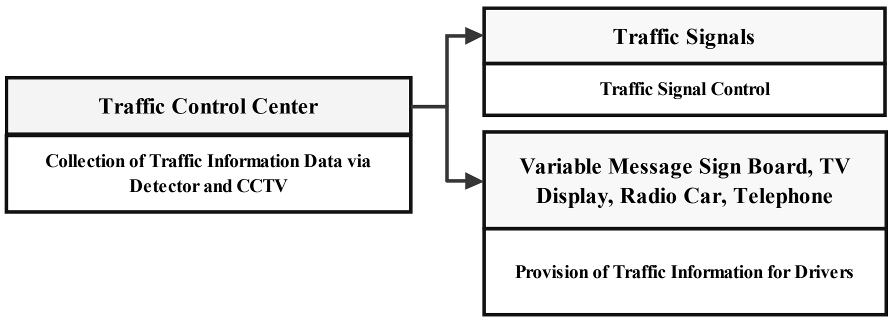


Figure 16.3-2 Relationship between the Traffic Control System and the Traffic Information System

1) Objectives for Supplying Traffic Information

By supplying emergency information such as accidents, abnormalities and traffic regulations, the following effects are aimed at:

a) Immediate notification of incidents to drivers;

b) Selection of routes, to prevent secondary congestion;
c) Traffic flows will be re-distributed as a result, and
d) Drivers can participate in the reduction of traffic problems by having such information and this will help to mitigate traffic congestion.

2) Information Supply

The following information will be supplied:

a) Information concerning route prohibition;
b) Information on congestion and route guidance for detour;
c) Road and traffic regulations, and
d) Other public information.

3) Location Information Indication Unit (Traffic Message Sign Board)

The center will be housed in the traffic signal control center and the information indication units will be installed at major crossroads on arterial roads, as shown in Figure 16.3-3. The information supply system includes an exchange of road & traffic information between the proposed future road networks.

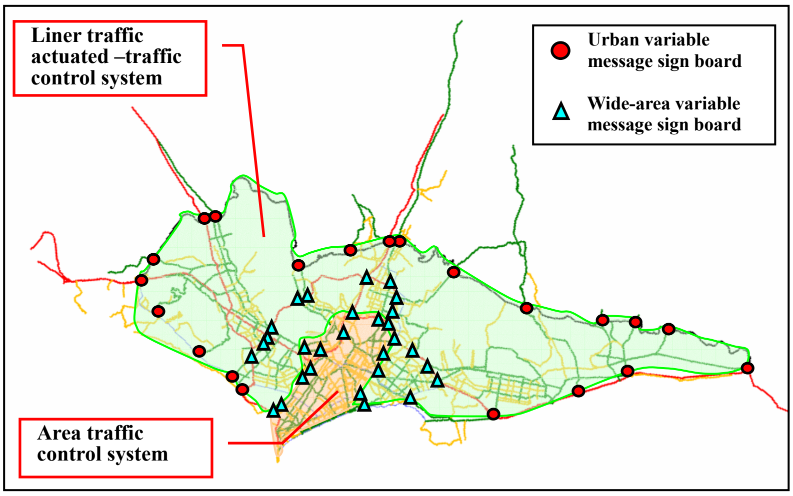


Figure 16.3-3 Location of Information Indication Unit (Traffic Message Sign Board)

4) Positive Collection and Accumulation of Data for the Traffic Center

To perform an adequate traffic control, the collection, accumulation, and analysis of various fundamental data, by location and by route, is essential. The following data should be collected and accumulated without exception. A database should be formulated and information supplied to those who are concerned with traffic control and study. The data will be collected by periodical surveys and vehicle detectors, etc.

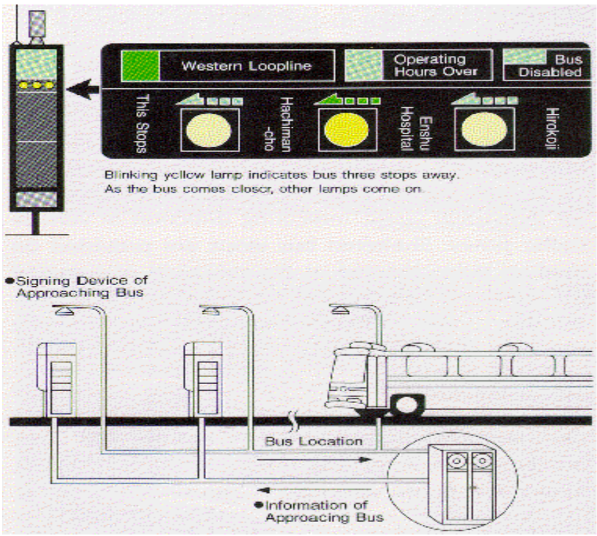
a) Traffic volume;
b) Traffic volume occupancy rate;
c) Travel speed, and
d) Conditions of traffic signal lights.

16.3.2. Bus Location Information System and Bus Priority Signal Control System on Trunk Roads

This section discusses the bus priority system for the medium and long terms by introducing the bus location information system and the bus priority signal control system at signalized intersections. This section introduces a brief description of these systems.

(1) Bus Location Information System

In terms of public transport, public transport service information such as time/fare table, route network, transfer points, operation schedule and bus location is considered to be important to the users. This information system does not alleviate traffic congestion directly, but indirectly by encouraging people to use the public transport mode. To alleviate passenger discomfort caused by unpunctuality and to improve the management of the operation, the bus location information system enables the individual display of the location of approaching buses at respective bus stops and an integrated display of locations of all buses under operation at the control center. The system will enable public transport operators to manage and control their business operations effectively and efficiently. Furthermore, the system will alleviate users' frustration towards unreliable services by displaying relatively accurate bus arrival schedules at bus stops. The system, therefore, is expected to increase public mode users extensively. Figure 16.3-4 shows an information board of the system and a mechanism of the system.



Source: "Urban Transport Facilities in Japan 1993", City Bureau Ministry of Construction and Japan Transportation Planning Association

Figure 16.3-4 Information Board and Mechanism of Bus Location System

(2) Bus Priority Signal Control System on Trunk Roads

In addition, in order to provide traffic signal priority, the bus priority traffic signal control system at signalized intersections is effective at the bottlenecks. The purpose of the bus priority signal control system is to realize punctual public transportation, improve convenience for bus users and promote car owners to use public transportation, giving priority to bus transportation. By implementing the system, public transportation will become more dominant, road traffic demand of private cars will be reduced, and traffic flows will become more efficient. When a bus passes under an infrared beacon at the local facility, the infrared beacon receives vehicle ID information from an in-vehicle unit installed in a bus and transfers the data to the Traffic Control Center. The Traffic Control Center, with vehicle ID information, traveling point and destination, controls traffic signals so that buses do not have to stop or shortens the waiting time at intersections as much as possible. Figure 16.3-5 shows the bus priority signal control system and a mechanism of the system.

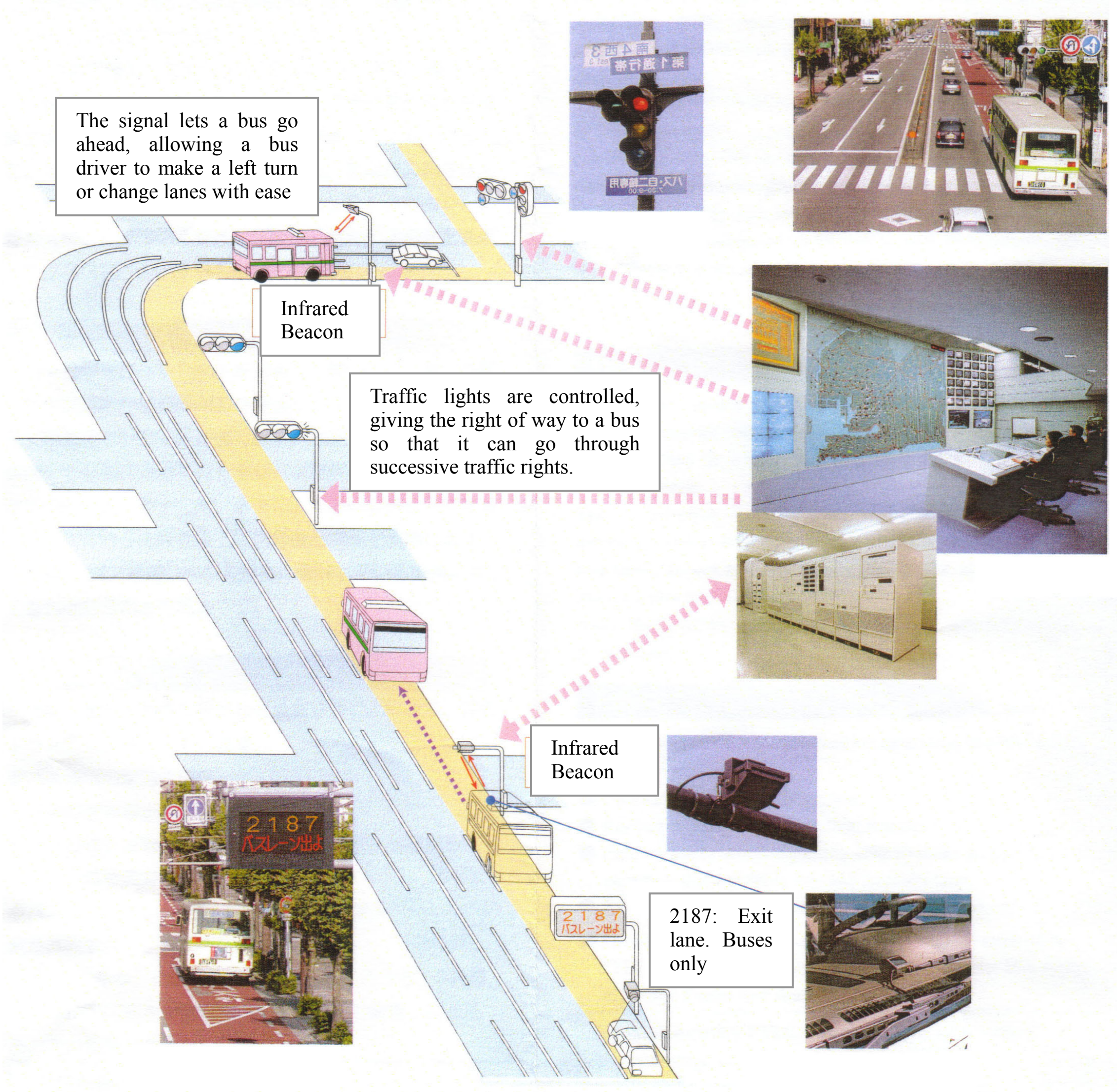


Figure 16.3-5 Bus Priority Traffic Signal Control System on Normal Roads

16.4. PROJECT COST FOR TRAFFIC MANAGEMENT SECTOR

The project cost for the traffic management sector is consists of 1) Improvement Plan of Traffic Signal Control System, 2) Improvement Plan of Intersection, 3) Plan of Traffic Demand Management System (TDM), 4) Improvement Plan of Traffic Safety Facilities, 5) Improvement Plan of Parking Control System, 6) Plan of Traffic Safety Education System, 7) Plan of Traffic Accident Monitoring System (Traffic Safety Audit System), 8) Improvement Plan of Vehicle Inspection System, 9) Area Traffic Control System and Traffic/Road Information System, and 10) Bus Location Information System and Bus Priority Signal Control System on Trunk Roads. The project cost by items is shown in Table 16.4-1.

Table 16.4-1 Project Cost for Traffic Management Sector

No.	Name of Project	Project Cost (x 1,000 US$)
1	Improvement Plan of Traffic Signal Control System	38,640
2	Improvement Plan of Intersections	650
3	Plan of Traffic Demand Management System (TDM)	5,540
4	Improvement Plan of Traffic Safety Facilities	650
5	Improvement Plan of Parking Control System	2,400
6	Plan of Traffic Safety Education System	1,620
7	Plan of Traffic Accident Monitoring System (Traffic Safety Audit System)	2,700
8	Improvement Plan of Vehicle Inspection System	20,800
9*	Area Traffic Control System and Traffic/Road Information System	50,000
10*	Bus Location Information System and Bus Priority Signal Control System on Trunk Roads	33,000
	Total	156,000

*Note: * Proposed measures for the middle and long-term plan*

1. Improvement Plan of Traffic Signal Control System

Items	Unit	Unit Cost (USD)	Quantity	Total Cost (x 1,000 US$)
1) Area Traffic Control (ATC) System				
a. Signal controller for planned intersection	Piece	17,500	17	298
b. Lamps for vehicles	Lamp	1,230	68	84
c. Lamps for pedestrian	Lamp	800	136	109
d. Poles of signal lights for both V/P	Pole	1,350	68	92
e. Cable of lamps	Unit	8,000	17	136
f. Vehicle detectors	Piece	1,400	2,602	3,643
g. Poles for detectors	Pole	500	1,078	539
h. Traffic control center	Unit	5,000,000	1	5,000
Sub Total				9,900
2) Synchronized System				
a. Signal controller for planned intersection	Piece	17,500	122	2,135
b. Lamps for vehicles	Lamp	1,230	488	600
c. Lamps for pedestrian	Lamp	800	976	781
d. Poles of signal lights for both V/P	Pole	1,350	488	659
e. Cable of lamps	Unit	8,000	122	976
f. Vehicle detectors	Piece	1,400	8,360	11,704
g. Poles for detectors	Pole	500	3,736	1,868
Sub Total				18,723
Total				28,623
Engineering Cost (Total x 10%)				2,862
Administration Cost (Total x 10%)				2,862
Contingencies Cost (Total x 15%)				4,293
Grand Total				38,640

Notes: Unit cist includes the earth works.

2. Improvement Plan of Intersection (in accordance with plan of traffic signal control plan)

Items	Unit	Unit Cost (USD)	Quantity	Total Cost (x 1,000 US$)
a. Earth work	Unit	150,000	1	150
b. Marking	Unit	330,000	1	330
Total				480
Engineering Cost (Total x 10%)				50
Administration Cost (Total x 10%)				50
Contingencies Cost (Total x 15%)				70
Grand Total				650

3. Plan of Traffic Demand Management System (TDM)

Items	Unit	Unit Cost (USD)	Quantity	Total Cost (x 1,000 US$)
a. Equipments and propaganda (Mass media)	Unit	500,000	1	500
b. Personnel expenses	Person	10	360,000	3,600
Total				4,100
Engineering Cost (Total x 10%)				410
Administration Cost (Total x 10%)				410
Contingencies Cost (Total x 15%)				620
Grand Total				5,540

4. Improvement Plan of Traffic Safety Facilities

Items	Unit	Unit Cost (USD)	Quantity	Total Cost (x 1,000 US$)
a. Pedestrian bridge	Unit	300,000	1	300
b. Scramble pedestrian crossing	Unit	180,000	1	180
Total				480
Engineering Cost (Total x 10%)				50
Administration Cost (Total x 10%)				50
Contingencies Cost (Total x 15%)				70
Grand Total				650

5. Improvement Plan of Parking Control System

Items	Unit	Unit Cost (USD)	Quantity	Total Cost (x 1,000 US$)
a. Equipments and propaganda (Mass media)	Unit	500,000	1	500
b. Road marking (3.0 m^2/space) of total 7,260 parking space	m^2	20	21,780	436
c. Traffic signs	Piece	300	380	114
d. Personal expenses for inspection (3 shift per 12 hours)	Person	4	180,000	720
Total				1,770
Engineering Cost (Total x 10%)				180
Administration Cost (Total x 10%)				180
Contingencies Cost (Total x 15%)				270
Grand Total				2,400

6. Plan of Traffic Safety Education System

Items	Unit	Unit Cost (USD)	Quantity	Total Cost (x 1,000 US$)
a. Equipments and educational materials	Unit	200,000	1	200
b. Mass media for propaganda	Unit	500,000	1	500
c. Personnel expenses for supervision (Experts)	Unit	300,000	1	300
d. Training course in other countries	Unit	200,000	1	200
Total				1,200
Engineering Cost (Total x 10%)				120
Administration Cost (Total x 10%)				120
Contingencies Cost (Total x 15%)				180
Grand Total				1,620

7. Plan of Traffic Accident Monitoring System (Traffic Safety Audit System)

Items	Unit	Unit Cost (USD)	Quantity	Total Cost (x 1,000 US$)
a. Equipments and educational materials	Unit	1,000,000	1	1,000
b. Personnel expenses for supervision (Experts)	Unit	500,000	1	500
c. Training course in other countries	Unit	500,000	1	500
Total				2,000
Engineering Cost (Total x 10%)				200
Administration Cost (Total x 10%)				200
Contingencies Cost (Total x 15%)				300
Grand Total				2,700

8. Improvement Plan of Vehicle Inspection System

Items	Unit	Unit Cost (USD)	Quantity	Total Cost (x 1,000 US$)
a. Equipments and devices	Unit	3,600,000	4	14,400
b. Building	Unit	50,000	10	500
c. Training course in other countries (capacity building)	Unit	500,000	1	500
Total				15,400
Engineering Cost (Total x 10%)				1,540
Administration Cost (Total x 10%)				1,540
Contingencies Cost (Total x 15%)				2,320
Grand Total				20,800

9. Area Traffic Control System and Traffic/Road Information System

Items	Unit	Unit Cost (USD)	Quantity	Total Cost (x 1,000 US$)
a. Traffic signal lights and local control unit	Unit	20,000,000	1	20,000
b. Variable message sings and local control unit	Unit	7,000,000	1	7,000
c. Traffic control center	Unit	10,000,000	1	10,000
Total				37,000
Engineering Cost (Total x 10%)				3,700
Administration Cost (Total x 10%)				3,700
Contingencies Cost (Total x 15%)				5,600
Grand Total				50,000

10. Bus Location Information System and Bus Priority Signal Control System on Trunk Roads

Items	Unit	Unit Cost (USD)	Quantity	Total Cost (x 1,000 US$)
a. In-vehicle units	Unit	12,000,000	1	12,000
b. Local control units	Unit	8,000,000	1	8,000
c. Traffic control center	Unit	4,445,000	1	4,445
Total				24,445
Engineering Cost (Total x 10%)				2,445
Administration Cost (Total x 10%)				2,445
Contingencies Cost (Total x 15%)				3,665
Grand Total				33,000

CHAPTER 17

Initial Environmental Examination (IEE)

17. INITIAL ENVIRONMENTAL EXAMINATION (IEE)

17.1. NATURAL CONDITION

17.1.1. LOCATION

The Study Area, the Metropolitan Area of Lima and Callao, is located on a skirts-end plain of the occidental flank of the Central Cordillera of the Andes Mountains, which latitude and longitude is 12 degrees south and 77 degrees west. The urban zone of the study area is located mainly on the costal plain with 20 Km of width and 50 Km of length, which elevation is from 0 to 200 meters above sea level.

17.1.2. CLIMATE

(1) General Aspects

The costal zone from northern Chile to Peru is a dry zone. This is because the south-eastern Pacific high pressure zone stays in this area all year round by the influence of the Humboldt Current, which is a cold ocean current that does not produce a lot of evaporation, though it is in a tropical area. The study area is located in this dry zone, which climate is desert with only 13 mm of annual precipitation. The annual mean temperature is about 20 degrees C, which annual range is about 9 degrees measured from 15.1 degrees C in winter to 22.2 degrees C in summer. Though the study area is in the desert, the daily range of temperature is as small as 7 degrees because of the influence of the ocean.

(2) Climatic Data

Climatic Data are shown in Table 17.1-1 to Table 17.1-4 and Figure 17.1-1 Figure to Figure 17.1-2 respectively.

1) Temperature

Table 17.1-1 Monthly Average of Daily Highest Temperature

(unit: ºC)

Alexander von Humboldt Station	Months												Annual Total (ºC)
	Jan.	Feb.	Mar.	Abr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	
Year 1999	27.3	28.8	28.6	26.2	24.3	20.7	16.9	19.4	20.1	22.1	23.0	24.7	23.5
Year 2000	26.6	28.1	28.6	27.0	23.5	19.5	18.1	18.9	19.6	21.7	23.1	25.0	23.3
Year 2001	27.6	29.3	30.1	27.4	22.6	18.9	18.1	18.8	19.7	21.0	22.8	24.9	23.4

Note: Humboldt Meteorological Station
Source: Technical and Environmental Studies of COSAC I

Table 17.1-2 Monthly Average of Daily Lowest Temperature

(unit: ºC)

Alexander von Humboldt Station	Months												Annual Total (ºC)
	Jan.	Feb.	Mar.	Abr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	
Year 1999	18.3	21.0	19.8	17.8	18.7	13.7	12.9	13.8	13.9	14.7	15.2	16.8	16.4
Year 2000	19.5	19.3	19.6	18.4	15.3	14.1	14.4	14.3	13.8	14.6	14.3	17.3	16.2
Year 2001	19.1	20.6	20.1	18.3	15.5	13.9	13.7	13.4	13.3	14.1	15.1	16.5	16.1

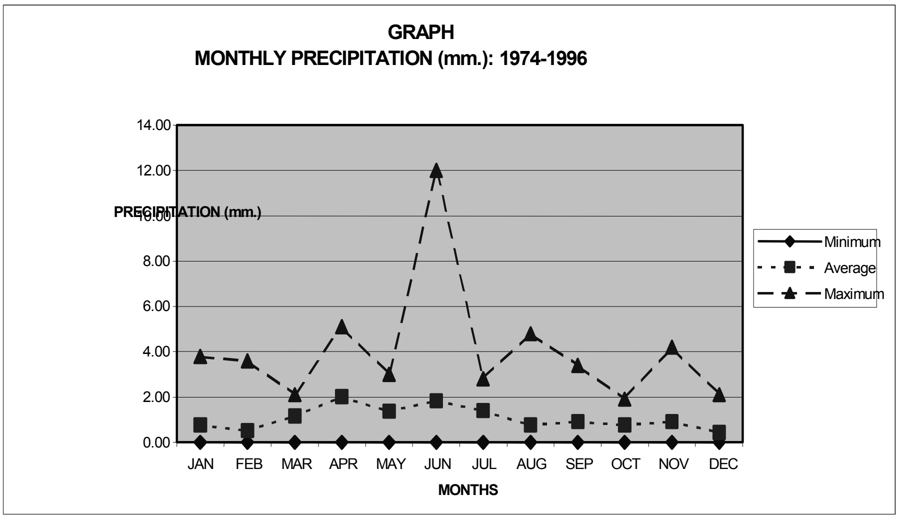
Source: ditto.

2) Precipitation

Table 17.1-3 Monthly Precipitation

(unit: mm)

Station	Months												Annual Total (mm)
Von Humboldt	Jan.	Feb.	Mar.	Abr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	
	0.7	0.8	0.5	0.7	1.2	2.0	1.4	1.8	1.4	0.8	0.9	0.4	12.6



Note: Average from 1974 to 1996 at Humboldt Meteorological Station
Source: Technical and Environmental Studies of COSAC I

Figure 17.1-1 Figure Mean Monthly Precipitation

3) Humidity

Table 17.1-4 Relative Humidity

(unit: %)

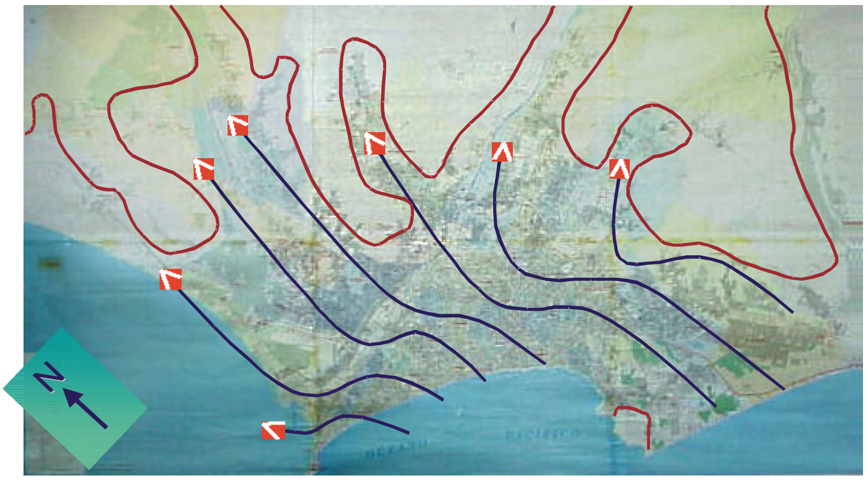
Alexander von Humboldt Station	Months												Annual Total (%)
	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	
Year 1999	81	79	84	91	92	93	94	88	87	85	82	81	86.4
Year 2000	88	76	73	72	86	88	95	93	91	88	86	83	84.8
Year 2001	83	80	76	83	83	92	93	91	84	88	81	85	84.9

Note: Humboldt Meteorological Station
Source: Technical and Environmental Studies of COSAC I

4) Wind

Winds from the South, Southeast and Southwest surpass winds of other directions all year around.

Average wind velocity is from 1 m/s to 4 m/s.



Source: Saturation Study 2001

Figure 17.1-2 Wind Direction Model

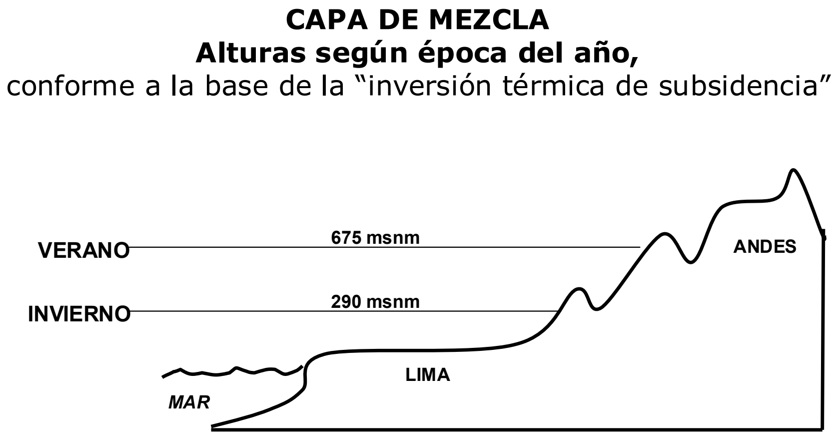
(3) El Niño Events

The El Niño Event is a phenomenon of climatic oscillation that characteristically shows a higher than average rise of seawater temperature in the eastern Pacific area and the Humboldt Current turns around to the west at more southern than normal altitude. This event also shows that the flow zone of Tropical West Wind, which brings wet air to the Andes Mountains, is brought down more to the south than usual, at the same time the Southern Inter-tropical Convergence (SITC) Zone, which is a confronting of Tropical West Wind against Southern Trade Wind, is brought down more to the south.

The altitude of Tropical West Wind is oscillated from south to north according to seasons, in winter it goes down to Northern Peru in a normal year. However, with the Current of El Niño it goes down more to the south and it brings extraordinarily heavy rainfalls in the Peruvian Andes Mountains. The El Niño event repeats itself every several years, in the recent record 1982-1983 and 1998 showed very remarkable rainfalls and produced a lot of disasters all over the country.

(4) Phenomenon of Temperature Inversion

It is reported that in the Study Area the phenomena of Temperature Inversion is current, the higher the layer goes the higher the temperature becomes, influenced by the cold ocean current flowing South to North near the coast. Actually, it is often observed in the coast that fog does not come up more than a certain height where there is an Inversion Layer. There is a report informing that the height of the Inversion Layer is 675 m above sea level in summer and 290 m in winter. When there is an Inversion Layer the polluted air does not spread away but stays concentrated in a lower layer. Many air pollution incidents in other countries, producing victims of the respiratory organ disease, occurred when there was Inversion Layer. It is necessary to take into consideration the Temperature Inversion when we analyze the impact of air pollution in the Study Area.



Source: Saturation Study 2001

Figure 17.1-3 Model of Inversion Layer of Temperature

Source: Saturation Study 2001

Figure 17.1-4 Model of Atmospheric Valleys in which the Polluted Air may remain

17.1.3. TOPOGRAPHY

(1) Department of Lima

There is the Central Cordillera of the Andes Mountains, which ridges running from South to North and located as near as 90 Km from the Pacific coast. Many peaks, more than 4,500 meters high, stand in a row along the ridge, including snow-covered Mt. Sarapo (6,127 m), Mt. Rasac (6,017 m), Mt. Ticlla (5,897 m) and others. This ridge is the limit between the Department of Lima and the Department of Junín and it is also the hydrological division of the two oceans. The railroad connecting La Oroya and Huancayo goes through the department limit tunnel at an elevation of 4,950 m above sea level, which is the highest railroad tunnel in the world.

On the other hand there is 4,500 meter deep Peru Trench 150 Km off the Pacific coast. The difference of height between the trench and the Andes ridge is more than 10,000 meters with only 240 Km of horizontal distance.

(2) The Study Area

The Study Area is located on a skirts-end small plain of the occidental flank of the Central Cordillera of the Andes Mountains. There are alluvial plains along the Chillón River in the north and the Lurín River in the south. There is an alluvial fan developed in the Rímac River Basin. The main part of the city of Lima is located on the fan-shaped plain of the Rímac River Basin, which develops in its north and south finger-shaped valleys in the palm-hand fan. In these valleys there are a lot of advanced urbanizations crowded with scanty houses reaching halfway up the mountains. In these surrounding mountains there are Mt. San Cristóbal (409 m), Mt. San Jerónimo (755 m), Mt. San Francisco (629 m), Mt. Puruchuco (666 m), Mt. Chivo (536 m) and others. The coast in the center of the Study Area is an elevated coast, which height is about 100 meters in the Costa Verde Seashore of the Miraflores District. This coastal zone forms a 15 Km long bow-shape ranging from La Punta Cape in the city of Callao to the Morro Solar Hill (273 m) of La Chira Cape in the Chorrillos District of Lima.

17.1.4. GEOLOGY

(1) Geological Structure

Off the Coast of Peru there is Peru Trench where the Nazca Plate of the eastern Pacific fronts against and goes beneath the South American Continental Plate. The Nazca Plate moves eastward by 5.6 cm a year, on the contrary the South American Plate moves westward by 3.2 cm a year. This confrontation produces huge-scale earthquakes of plate boundary in this zone, which is a globally known seismic belt. The most remarkable seismic event in history was that of 1746, that destroyed central Lima and Callao accompanied by a tsunami.

There are also frequent earthquakes inside of the Continental Plate caused by the movement of geological faults. The well-known geological faults in the study area are, in the north, the Zapallal fault with range of northwest to southeast, in the center-north, the Pueblo Viejo fault with range of north to south and, in the center-south, the José Galvez fault with range of north to south.

(2) Superficial Geology

The major part of the Study Area is made up of formations of the Quaternary. The plains developed by the Chillón River, Rímac River and Lurín River are alluvial plains of Pleistocene. There are formations of wind erosion on the coastal hills in Pachacámac and in Santa Rosa. There are marine sedimentary formations of Pleistocene and Holocene in the Villa and Ventanilla Districts. Mt. San Cristóbal, Mt. San Jerónimo and Mt. San Francisco, which can be seen from the center of the study area, are made up of granodiorite porphyry and other intrusive volcanic rock. These mountains are left un-eroded because of their hard quality.

17.1.5. HYDROLOGY

The scope of the Study Area includes the Chillón River Basin in the north, the Rímac River Basin in the center, and the Lurín River in the south, which areas are 1,250 Km^2, 2,250 Km^2 and 680 Km^2 respectively (See Figure 17.1-5 to Figure 17.1-7). The origins of these rivers are in the Central Cordillera of the Andes Mountains, about 90 Km east from the Pacific coast. The falling grades of these rivers are very steep, the volume of which water varies tremendously depending on seasons. Floods are frequent along in the Rímac River in the Study Area. The underground water level in the central area of Lima is generally deep, sometimes more than 70 meters deep, because of the existence of sand and gravel. Underground water is utilized for urban and agricultural use, sometimes pumped-up from depths of more than 200 meters (Figure 17.1-8). On the other hand, there are not many but some fountains of underflow water in the end of the alluvial fan, for example in the Villa Swamp in the Chorrillos District.

Chillón River, Ventanilla District

Rímac River, Lima District

Figure 17.1-5 Chillón River

Figure 17.1-6 Rímac River

Lurín River, Pachacámac District

Underground water service in Lurín River Basin, Lurín District.
Private companies provide potable water to people without public water supply.

Figure 17.1-7 Lurín River

Figure 17.1-8 Underground Water Service

17.1.6. SOIL

The soil of the upper areas of the study area is non edaphic sand and gravel, and is not suitable for the use of agriculture, livestock farming and forestation. The soil of the coastal zone is the same as this. In the plain area there is alluvial soil interfered by urbanization. The alluvial soil along the Rivers of Chillón, Rímac and Lurín presents a medium level of fertility.

17.1.7. VEGETATION

No natural vegetation is seen in the Study Area because of the desert climate, only except for a little lichen in the slopes that receive wet air from the sea in the mornings and evenings. The surrounding small mountains show a completely gray landscape (See Figure 17.1-9). Only in the mountain area, of more than 600 meters of elevation, there is natural vegetation where there is precipitation caused by ascending wet currents from the sea. As the Study Area is thoroughly urbanized, all of the plants there are planted artificially and maintained by irrigation.

On the other hand, in the areas along the Chillón River, Rímac River and Lurín River there is swampy vegetation of tall reeds and cultivated fields (See Figure 17.1-10). In these zones there were agricultural areas; however, 496 km have disappeared during the last 85 years until 1995 as a result of the rapid urban expansion.

Desert Landscape, Pachacamac District

Figure 17.1-9 Desert Landscape

Cultivated Field along the Lurin River, Lurin District

Figure 17.1-10 Cultivated Field

17.1.8. FLORA

As the Study Area is in desert there are no trees and shrubs of natural flora and almost no herbaceous plants.

17.1.9. FAUNA

As the Study Area is thoroughly urbanized there is almost no place where natural fauna can be observed. Domestic animals, birds and animals adapted to human environment can be seen in the area. In the following sites natural fauna can be observed.

(1) Villa Swamp Natural Reserve

There exists the Villa Swamp in the Chorrillos District in the center south of Lima. The swamp was formed by closing a bay mouth bar at the south of La Chira Cape. Here, inland water springs out, coming through strata of sand and gravels. This is an important place of transit for migratory birds coming up and down between North and South America, where more than 160 species are observed. See Figure 17.1-11. This swamp is preserved as an ecological park (Reserved Zone of the Ecological Park of the Villa Swamps), though it is surrounded by a golf course and urban area.

	
Villa Swamp Natural Reserve, Chorrillos District	Bird-watching Platform in the Villa Swamp Natural Reserve

Figure 17.1-11 Villa Swamp

(2) Ventanilla Swamp

In the north of Callao there is the Ventanilla Swamp, with a mixture of seawater and inland water, which is a well-known place of transit for migratory birds, however no special preservation is operated.

(3) Palomino Islands

Behind San Lorenzo Island, near La Punta Cape, and just at 10 Km of direct distance from the city center of Callao, are the Palomino Islands, which are very famous for its habitat of sea lions.

The area around the islands is a very good fishing ground, where sea water of deep strata comes up pushed by the Humboldt Current because of submarine topography. The deeper water contains more minerals and this makes rich fauna of krill and other planktons. This is why the area is rich in fish and fish-eating animals. In ancient times, San Lorenzo Island was covered fully with guano or sediment of excrements of birds and looked very white; however, nowadays guano has been completely removed since it is a very good phosphatic fertilizer. San Lorenzo Island does not look at all like what the island was before.

The Palomino Islands are made up of tiny islands of less than one hectare where there are colonies of sea lions that range from 3,000 to 10,000 units. The number of sea lions fluctuates widely because they are very sensitive to the climatic change of El Niño. After a drastic reduction, it takes 4 or 5 years to recover the number of inhabitants. And thus, the up and down cycle is repeated every several years. The sea water is cool because of the Humboldt Current, though it is in the tropical zone, 17 degrees C in winter and 21 degrees C in summer. For the reference, the area of the islands is not preserved specially, the area of San Lorenzo Island and El Frontón is a military control area, where there was a prison of important political offenders at the time of the Garcia administration.

17.1.10. CLASSIFICATION OF ECOLOGICAL LIFE ZONES

According to the classification of ecological life zones, more than 90 % of the Study Area, which is plain area, belongs to the Subtropical Desiccated Desert (dd-S). The northeast part of the study area, which is skirts end of mountain, belongs to the Subtropical Super-dry Desert (ds-S). The area of higher elevation than that of ds-S, the eastern limit of the study area, belongs to the Tropical Low-mountain Semi-dry Desert (dp-PT).

17.2. SITUATION OF NATURAL AND SOCIAL ENVIRONMENT

17.2.1. NATURAL ENVIRONMENT

(1) Atmosphere

1) Topographical and Meteorological Conditions

The following remarkable characteristics of the topographical and meteorological conditions are presented in the study area:

a) In the study area southern, southwestern and southeastern winds surpass others all year around. The directions of winds coincide almost with those of finger-shaped valleys in the palm-hand fan in the eastern part of the study area. This makes the polluted air to be blown toward the finger-shaped valleys.

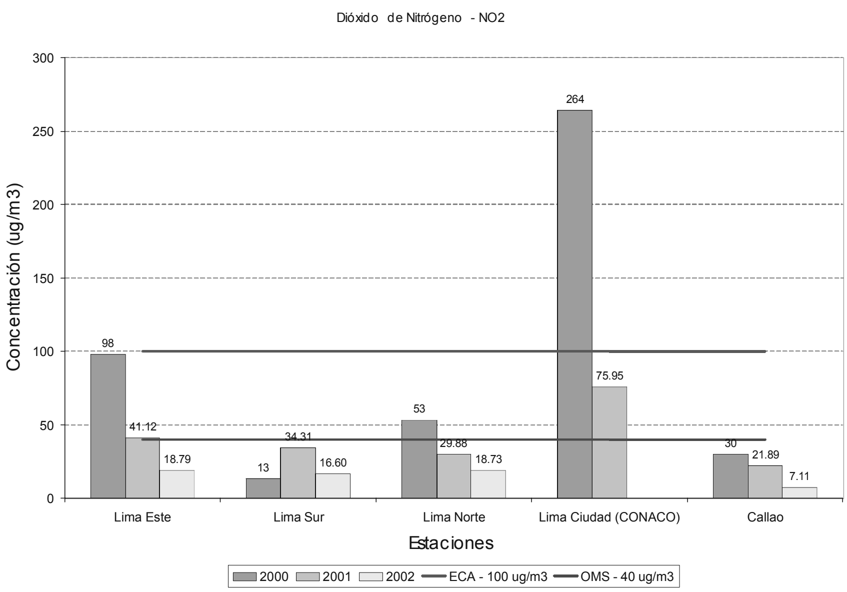
b) In the study area the phenomenon of Inversion Layer of Temperature often occurs, influenced by the ocean currents. There is a tendency that polluted air does not spread away but stays concentrated below a lower layer when there is an Inversion Layer and especially no wind.

c) The study area is generally a bit cloudy due to the influence of the Humboldt Current, though it is in the desert. However, during the summer there are many sunny days with a strong sunshine and ultraviolet rays (monthly sunshine time is more than 200 hours in summer). In these cases production of oxidants will be estimated.

2) The Situation of Air Pollution

The situation of air pollution is shown in Figure 17.2-1 to Figure 17.2-5 respectively.

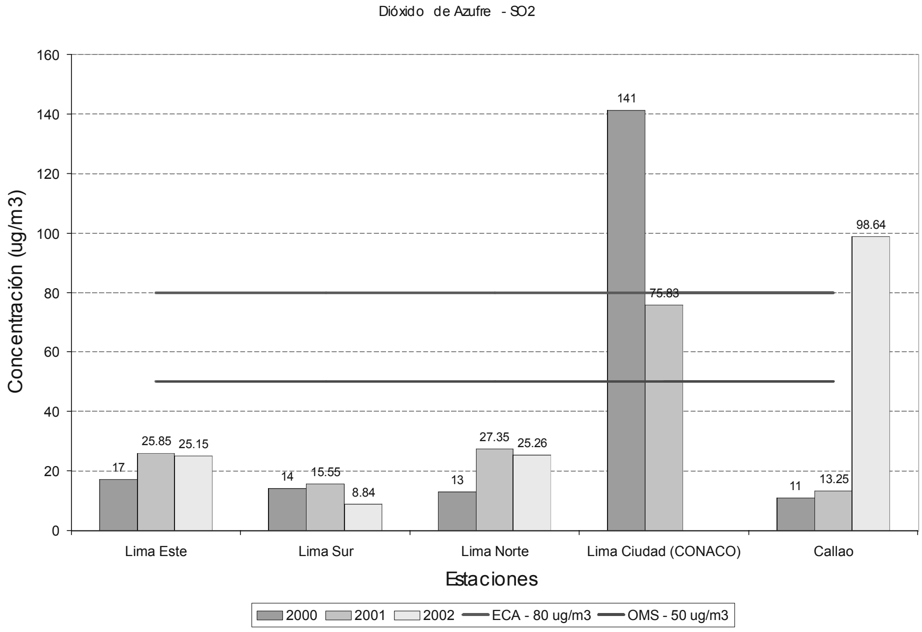
a) Nitrogen Dioxide



Source: Technical and Environmental Studies of COSAC I

Figure 17.2-1 Situation of Nitrogen Dioxide Pollution

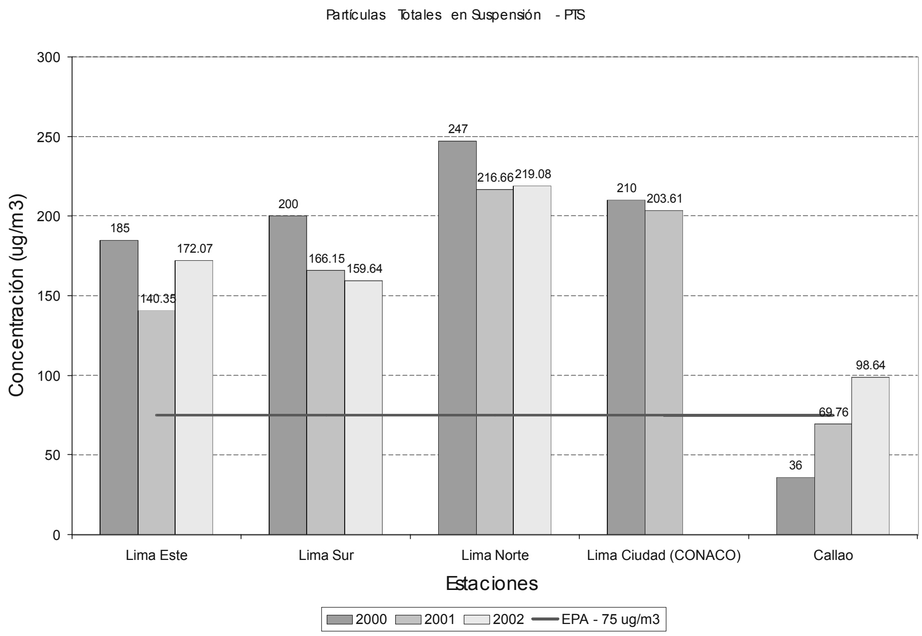
b) Sulfur Dioxide



Source: Technical and Environmental Studies of COSAC I

Figure 17.2-2 Situation of Sulfur Dioxide Pollution

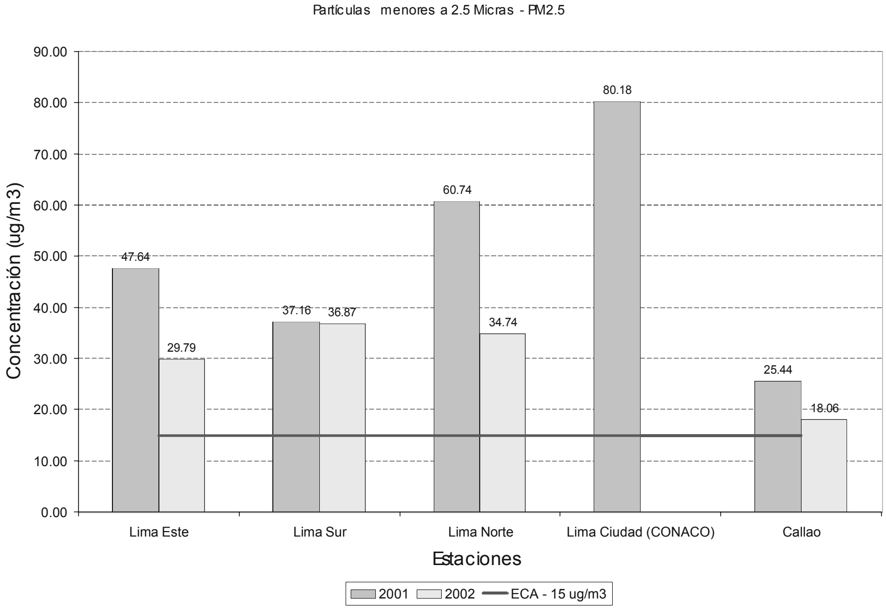
c) Suspended Particulate Matter smaller than 10 μ (PM-10)



Source: Technical and Environmental Studies of COSAC I

Figure 17.2-3 Situation of Total Particulate Matter (SPM, PM-10) Pollution

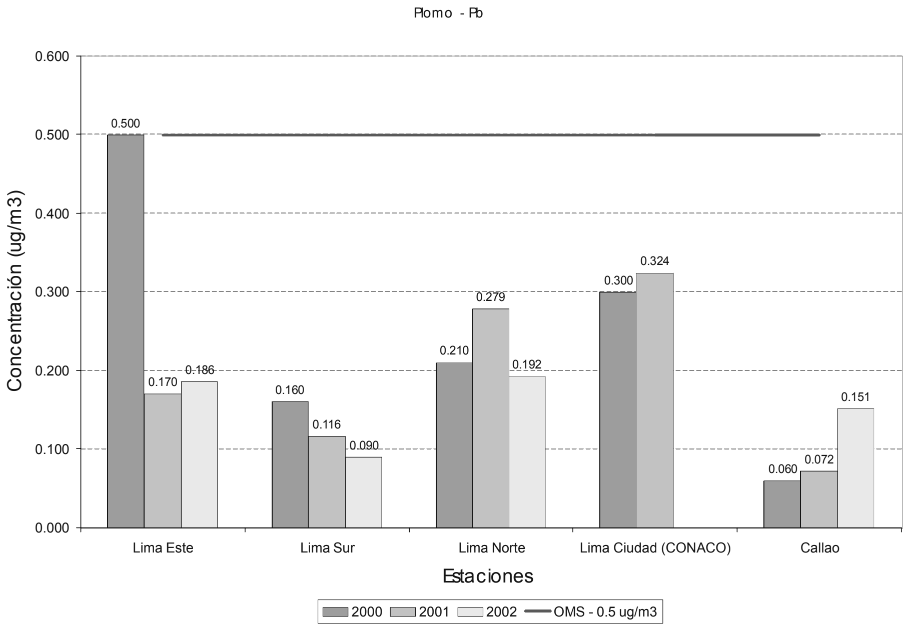
d) Suspended Particulate Matter smaller than 2.5 μ (PM-2.5)



Source: Technical and Environmental Studies of COSAC I

Figure 17.2-4 Situation of Particulate Matter (PM-2.5) Pollution

e) Lead



Source: Technical and Environmental Studies of COSAC I

Figure 17.2-5 Situation of Lead Pollution

3) Standard of Environmental Quality of Atmosphere

The national standard of environmental quality of atmosphere is determined by the supreme decree No.74 of 2001 in 7 different pollutants such as Sulfur Dioxide, Suspended Particulate Matter smaller than 10 μ (SPM, PM-10), Carbon Monoxide, Nitrogen Dioxide, Ozone, Lead and Hydrogen Sulfide. However, the system of observation and control is not enough, as there is only one measuring station of the Ministry of Health and only one set of mobile measuring machines. It will be necessary to establish a manual of measuring, a system of measuring at fixed periods and fixed sites, in order to capture the yearly change of pollution.

4) Permissible Emission Limits of Automobile Exhaust Gases

The Permissible Emission Limits of automobile exhaust gases is determined by the supreme decree No.47 of 2001 according to production year for gasoline vehicles in Carbon Monoxide (volume %), Hydrocarbons (density ppm), total of Carbon Monoxide and Carbon Dioxide (volume %), and for diesel vehicles in opacity of exhaust gases (black smoke). However, the system of measuring and control has not yet been established due to the lack of machines and facilities.

5) Lead Pollution by Automobile Fuel

In Peru, chemical compound of lead is still currently added to automobile fuels. The supreme decree No.19 of 1998 was promulgated so as to eliminate 95-octane lead gasoline from the market and to reduce lead down to 0.14g/l of 95-octane gasoline by July of 2003. However, no fuel supplying company could observe this decree by the time limit. Another supreme decree No.34 of 2003 was promulgated so as to postpone the time limit until December 31st of 2004.

6) Sulfur Pollution by Automobile Fuels

The automobile fuels consumed in Peru are imported from Nicaragua. These imported fuels contain a high level of sulfur. Light oil for diesel contains as much as 5,000 ppm of sulfur, gasoline is also supposed to contain considerable amounts of sulfur. According to a report from the Lima and Callao Clean Air Management Initiative Committee, there was a target plan so that lead might be reduced down to less than 150 ppm in gasoline and less than 1,500 ppm in diesel oil, however, currently (December of 2004), no regulations have yet promulgated it.

7) Efforts of Lima and Callao

In the metropolitan area the situation of air pollution is getting worse year by year. In 1998 the Lima and Callao Clean Air Management Initiative Committee was established for considering the countermeasure. In 2002 the Lima and Callao Integral Atmospheric Security Plan (PISA) was created and has now progressed. In the provincial government of Lima, the Special Project Office for Environmental Recuperation in the Metropolitan Area was established for environmental management.

(2) Lead Pollution in Loading and Unloading of Lead Ore

Peru occupies the No.1 position in Latin America in the exportation of lead ore, and No.4 in the world. This is important revenue of foreign currencies for the country. The Callao Port manages as much as 90 % of the exportation of Peruvian lead ore. After it is transported to the port area, the lead ore is unloaded and deposited temporally before being loaded to mineral boats. When unloading and loading in the port area lead dust is raised in the air and has contaminated the soil around the port for a long time. The unloading and loading has been continued for more than 80 years without any control. Recently, epidemiological studies have discovered lead poisoned patients whose blood contains lead concentrated 4 times the WHO limit.

Therefore, Callao published a Provincial Decrees that obliged mineral transporters to construct huge transshipment facilities into which mineral trains and trucks should enter, and where unloading and loading of the minerals should be done in completely closed conditions and no dust could spread out. The facilities were constructed in 2003 and the problem was almost resolved at present.

(3) Noise

1) Noise from Automobiles

In the Metropolitan Area most of the noise problems are of mobile sources of motorcars. The streets of the central city are flooded by motorcar noises, additionally to klaxons sounded by drivers more than necessary, which might be part of the traffic culture of the city. The Standard of Environmental Quality of Noise is provided by Supreme Decree No.85 of 2003. The noise levels have to be maintained within the standards determined according to land zones such as Special Protection Zones, Residential Zones, Commercial Zones and Industrial Zones, and at the same time according to day time (from 07:01 to 22:00) and night time (from 22:01 to 07:00).

2) Airplane Noise at Lima International Airport

Airplane noise problems at Lima International Airport in Callao have come up to the surface, as bigger planes have increased and with more frequent landing and taking-off than before. The urbanization around the airport has also progressed in the recent years. The Provincial Government of Callao is preparing a bill of ordinance that obliges airline companies to adopt low-noise taking-off methods recommended by the International Civil Aviation Organization.

(4) Vibration

There is no regulation for vibration management in Peru, neither measuring nor control.

17.2.2. SOCIAL ENVIRONMENT

(1) Population Inflow to Metropolitan Areas

According to the national census of 1993 the total population of the Provinces of Lima and Callao is 6,434 thousand. As the national population is 22,639 thousand, 28.4 % is concentrated in these two cities. The average rates of population increase from 1988 to 1993 are 2.3% in Lima and 3.5% in Callao. The cause of population increase is mostly social population movement, that is, influx of people into the cities. Examining the population movement between departments, in 5 years from 1988 to 1993, 647 thousand people moved into the Province of Callao and the Department of Lima from other departments where they were born. In 1993 as many as 2,392 thousand people, or 33.6% of the total population of the Province of Callao and the Department of Lima (7,127 thousand), came from other departments where they were born.

(Note: The moving-out population from the Province of Callao and the Department of Lima to other departments is as small as 284 thousand in the same 5 years. In 1993, 317 thousand people who were born in the Province of Callao and the Department of Lima lived in other departments. Callao is a constitutional province that does not belong to any department.)

It is assumed that the influx of people into metropolitan cities has advanced for more than 10 years after the 1993 census. The population density is 2,475 persons / km^2 in the Province of Lima, and 5136 persons / km^2 in the Province of Callao, estimated for 1999 by the National Institute of Statistics and Information (INEI).

(2) Background of Population Inflow

One of the causes of the population inflow is the impoverishment of the rural economy. Examining the rate of economic growth, that of the agricultural sectors is 1.7% in average in 10 years until 1992, however the rate went down to -0.6% in the last 10 years until 2001, whereas in the same periods the national growth of GDP recorded -0.8% and 0.6% respectively. In 2002 the national growth went up to 5.2%.

Secondly are the displacements due to guerrilla conflicts, border strives, natural disasters, development projects, and so on. The guerrilla conflicts produced 25,000 victims in 13 years until 1998 and obliged 60,000 families to move into urban areas. The physical damage is estimated at about 20,000 million US Dollars in the same period. The situation was specially serious in the Departments of Ayacucho, Apurímac and Huacavelica located in the southern mountain region called Sierra Sur.

The border strives with Ecuador forced 17 provinces to be evacuated. The unusual climatic change of the so-called El Niño produced heavy rainfalls in the mountain areas and caused natural disasters. El Niño appeared very strongly in 1982-1983 and 1998, and 100,000 families were affected directly by disasters. These disasters accelerated the outflow of population. There are also displaced people evacuated from dam development sites, strip mining sites, disaster danger zones, waste damping grounds, and so on. The majority of these people are poor and tend to come to urban areas for survival.

(3) Illegal Occupation Problem

Poor people who have come from rural regions without jobs tend to live, for example, in the foot of mountains in the metropolitan area. In most cases they live in shelters of self-construction on land without proprietorship. This is so-called invasion. It is estimated that there are more than 2 million people living in invaded shelters, through there is no trustworthy statistic figure for them.

In Peru there is a social common sense that land should be obtained by a person who is capable to develop and utilize it, and the land regulation system is established on the basis of this social common sense. For example, a person who has occupied a land and lived there for more than 10 years will have the right of possession of the land and will obtain the right to claim its proprietorship. The same is true for a person who has occupied another person's property and lived there peacefully for more than 10 years without reclamation from the proprietor. A person who is occupying another person's property does not have sense of invasion, but is expecting for future possibility of possessive right and proprietorship. This is an occupation without ill will.

In Peru it is considered that properties without ownership basically belong to the nation. In many cases there are shelters invading these kinds of national lands. When an invaded land is once formed as a stabilized settlement with a considerable population the administrative authority inevitably legalizes the occupation and gives the occupants titles of property. Then electric energy and water will be supplied officially. This kind of legalization is called Titulación or titling. In the time of the Fujimori administration, COFOPRI (Commission of Informal Property Formalization) was established to manage titling. However, accelerated titling without sufficient studies sometimes produced confusion, some of which caused contradictions against public projects.