CHAPTER 7

CONFIRMATION OF SUITABILITY OF APPLIED TECHNOLOGIES

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7.1 Superiority of Japanese Railway Technologies

7.1.1 Rolling Stock

In Japan, the EMU system is used not only in commuter transport but also in high speed rail. Japan is one of the countries where commuter train transportation has the biggest volume. EMUs for commuter trains are capable of transporting passengers punctually and reliably at adequate speed, playing a key role as the transportation system in and around metropolitan cities. Japan is a world pioneer in high-speed rail and EMU systems instead of traditional loco-hauled and has been used from the start. Its technologies are continually being improved and developed to enhance passenger riding comfort, and make riding the trains more efficient, reliable and environmental friendly. They are naturally applicable to semi-high speed rail also.

In this project, both types of EMU, commuter and semi-high speed, are proposed. Therefore, Japan has much experience in this area and has led other countries in introducing optimum rolling stock.

Particulars of these technologies are light-weight car structure, highly efficient propulsion system and easy-maintenance structure.

a) Light-Weight Technology

Weight of Rolling stock directly affects operation energy consumption and thus operation cost. Besides, light weight rolling stocks have an advantage in construction of compact infrastructure because light weight reduces load resistance of the infrastructure, resulting in reduction of construction cost.

Japanese rolling stock manufactures along with railway operation companies have been pursuing light weight technology and now they are excellent in this field. Especially, technology of light weight stainless structures has made possible cars as light in weight as those with an aluminum alloy body. In Japan, stainless steel as well as aluminum alloy is used for metro and commuter rolling stocks.

b) Efficient Propulsion System

Induction motors and VVVF with IGBT systems are the most popular recent propulsion systems for rolling stock. It is energy efficient and requires less maintenance. However, technology in this field is constantly advancing, seeking more efficient systems.

Permanent magnet synchronous motors (PMSM) is the one example of the latest technology. PMSM has permanent magnets in its rotor, and makes the most use of the magnetic energy. So the efficiency of MPSM is even higher than that of an induction motor. This contributes to less energy consumption. Since PMSM generates less heat, fully hermetically enclosed structures would be possible and this contributes to maintenance reduction. Nowadays some manufactures in Japan are developing VVVF-inverter with silicon carbide (SiC) modules, which is more efficient than a conventional IGBT inverter. The best-suited system could be selected from among a variety of systems, considering cost performance.

c) **Easy-Maintenance Structure**

Maintenance is one of the most important subjects which influences the reliability of rolling stocks. Additionally, it is desirable to reduce maintenance work because it accounts for a certain portion of operation cost. The structure of bolster-less bogies is very simple and reduces the number of wearing parts. Automatic inspection functions of train information management system and self-diagnosis functions for major equipment save maintenance work. Rolling stocks manufactured through Japanese technology satisfy both high reliability and easy-maintenance.

7.1.2 Train Operation Management

1) Mix Train Operation

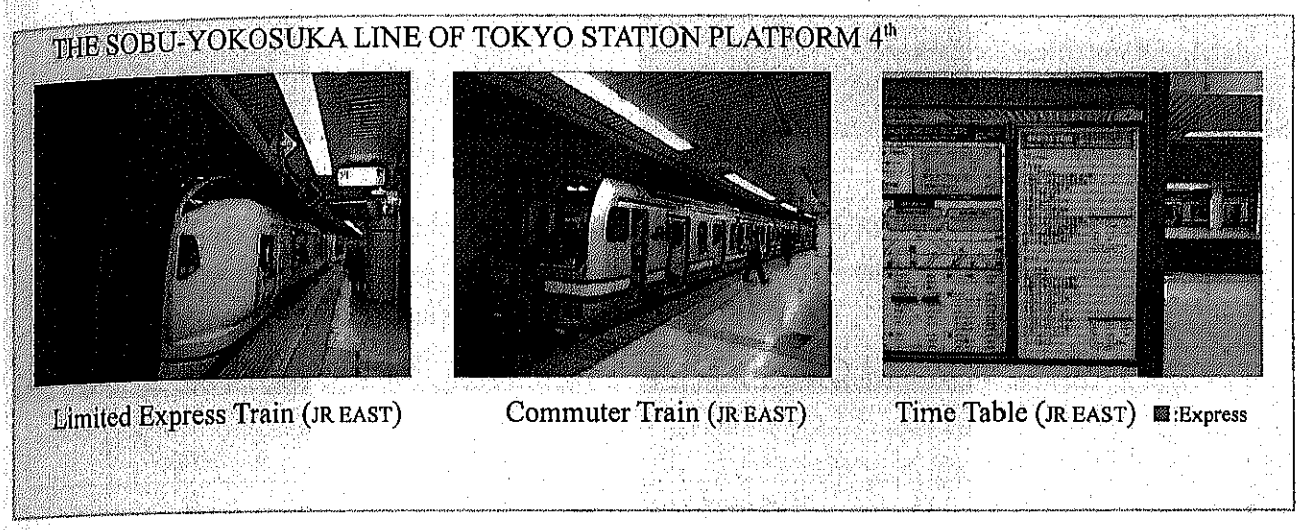
One of the features of Japanese commuter train operation is dense train operation. The most dense line is the Chuo line Rapid Service of JR EAST. The headway of this line is almost 2 minutes at peak hours. And there are 4 types of train services, Rapid transit and express train service. The stops of each train are different to reduce travel time. Many passengers that need a long time to commute want to arrive at their office or home earlier. It is complex to make a train operation plan and it is hard to maintain punctual train operation. Especially, it is hard to recover normal operation from transport disorder. Many Japanese railway operators struggle to keep safe and stable train operation. Their Know-how and technique in keeping train operation punctual, stable, and especially safe is useful for the AER PROJECT.

Source: JICA Study Team

Figure 7.1-1 Example of Mixed Train Operation 1

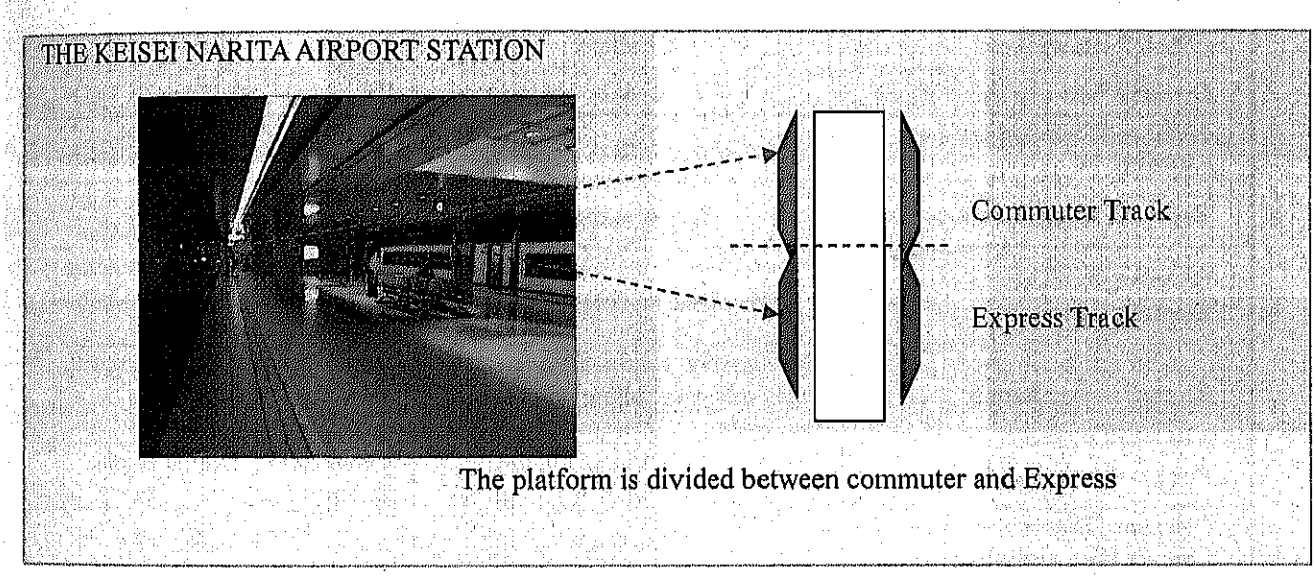
2) Airport Access Train Service in Japan

Narita International Airport in Japan is about 100km from the Greater Tokyo metropolitan area. Airport access limited express train service begun in 1991 by JR EAST and KEISEI. Both limited express train services use the existing railway line. And both existing railway lines are densely commuter lines too. There are mixed train operation with Commuter trains and limited express trains. It is hard to make a train operation plan for this especially in the morning and evening rush hours. It is necessary to consider facilities to pass and turn-back for limited express trains because running speed and headway are different from each other. This AER is similar to the Japanese Airport access train service. So Japanese railway operator's know-how and techniques regarding airport access train operation is very useful for this AER PROJECT.



Source: JICA Study Team

Figure 7.1-2 Example of Mixed Train Operation 2



Source: JICA Study Team

Figure 7.1-3 Example of Turn-Back Facility

7.2 Safe Train Operation

7.2.1 Electrification System

1) Feeding System

In order to select the electrification system of AER, the features of DC electrification and AC electrification are shown in Table 7.2-1.

Table 7.2-1 Comparison between DC and AC Electrification

	DC Electrification	AC Electrification
Typical Voltage	DC1500V	AC 2x25kV
Feeding System	Overhead Catenary (High speed) 3rd Rail(Middle speed)	Overhead Catenary
High Speed Railway	Good Up to around 200km/h	Excellence 300km/h and over
Long Distance Railway	Good	Excellent
Urban Railway	Excellent	Good
Distance between Substations	6~8km	30~70km
Number of Substations per 100km	13	2
Expected Electric Failure	Electric corrosion	Communication failure due to electromagnetic induction
Handling and Control of Electric Power	Low voltage is easy to handle.	Due to high voltage, grounding control is important especially at passenger stations.
Electric Power Supply	High-tension voltage network to uniformly cover along main line is required.	High-tension voltage lines with large power capacity are required.
Future Extension Plan	Extension for short or middle distance is better.	Extension for middle or long distance is better.
Clearance Distance between Contact Wire and Structure	150mm and over	300mm and over

Source: JICA Study Team

In order to document the electrification plans implemented by North Rail in the past, the flow of change of the proposed electrification system is shown in Table 7.2-2.

Table 7.2-2 History of the Electrification Plan of North Rail

No.	Year	Submitted by	Title	Description about Electrification
1	1996-1997	Spanish Railways Group	Technical Documents	• Basic design of electrification
2	Mar.1998	North Rail	Revised F/S MANILA–CLARK Railway System Project	• Evaluation of DC and AC traction system • Adoption of 25kV AC at 60Hz
3	Feb.2000	North Rail	F/S for MANILA – CLARK Rapid Railway System Project Section 1 (Monument–Calumpit)	• (ditto)
4	Mar.2003	North Rail	F/S for North Rail Project Phase 1, Section 1 (CALOOCAN-MALOLOS)	• Initially, Diesel traction is used. • Upgrade to Electric traction after warranty of DMU. • Evaluation of Electric traction has not been done.
5	Sep.2008	China National Machinery & Equipment Corporation	North Luzon Railways Project Phase 1, Section 1 (CALOOCAN-MALOLOS)	• Adoption of 1x25kV AC. • Power demand is 2x31.5MVA. • In the future, upgrade to the v/v connection transformer.
6	Nov.2008	SYSTRA ESCA SPI Joint Venture	Report on the 25 kV Electrification	• Review of Chinese proposal. • 1x25kV and 2x25kV has been proposed. • Power demand is 39 MVA. • Measure of electric failure has been proposed. (unbalance, etc)
7	Nov.2008	(ditto) SES-JV	MERALCO - Minutes of Meeting	• MERALCO rejected 1x25kV system and recommended 2x25kV system. • SES-JV agreed to adopt 2x25kV.

Source: JICA Study Team

Based on the above-mentioned background, the JICA study team carried out a 25kV system (AT feeding system) proposal to the following electric power companies. The outline of the discussion is shown in Table 7.2-3.

- National Grid Corporation of the Philippines (NGCP) in San Fernando
- San Fernando Electric Light & Power Co., Inc. (SFELAPCO)
- MERALCO Corporate Business Group

Table 7.2-3 Result of Study by the JICA Study Team

No.	Date	Electric Company	Outline of Discussion
1	18Jan,2013	NGCP	• JICA proposed 2x25kV system and Measure of electric failure • Power demand is 43.1MVA in 2025 • NGCP replied that power supply to 2x25kVsystem is possible. • However the impact has to be checked by NGCP.
2	18Jan,2013	SFELAPCO	• JICA proposed 2x25kV system and Measure of electric failure • Power demand is 43.1MVA in 2025 • SFELAPCO understood JICA's proposal regarding the AER project. Since the power demand of the AER project is huge, SFELAPCO will examine the means of being able to supply power to AER, from now on.
3	21Jan,2013	MERALCO	• JICA proposed 2x25kV system and Measure of electric failure • Power demand is 42.5MVA in 2025 • MERALCO replied that all JICA's requirements can be accepted.

Source: JICA Study Team

As a reference for selecting a feeding system for the Airport Express Railway (AER), Table 7.2-4 shows the feeding systems which are currently being used in each country.

Table 7.2-4 Outline of Feeding Systems of Each Country

Current	Feeding system	Range of Application	Main Countries which have adopted
DC 600V	Third rail	Metro	UK, U.S.A, Canada, Japan
DC 630V	Third rail	Metro	UK
DC 750V	Third rail	Metro	U.S.A, France, Germany, Japan
		LRT	Australia
		Suburban railway	UK
	Overhead line	LRT	Philippine
DC 800V	Third rail	Urban railway	Germany
DC 900V	Third rail	Metro	Belgium
DC 1000V	Third rail	Metro	U.S.A
DC 1200V	Third rail	Urban railway	Germany
DC 1500V	Third rail	Linear metro	China
	Overhead line	Metro	UK
		Urban railway Conventional Railway	Philippine, France, Australia, Japan
DC 3000V	Overhead line	Conventional railway	Belgium
AC 11kV	Overhead line	Long distance railway	U.S.A
AC 12.5kV	Overhead line	Long distance railway	U.S.A
AC 15kV	Overhead line	High speed railway	Germany
AC 20kV	Overhead line	Conventional railway	Japan
AC 25kV	Overhead line	High speed railway	UK, France, Belgium, Japan, China
		Long distance railway	U.S.A, Canada, Australia
		Suburban railway	Argentine, Venezuela
		Urban railway	India

Source: JICA Study Team

The following tendencies can be found from Table 7.2-4. A feeding system utilizing AC25kV is suitable for high speed railways with mass transport, since it can supply sufficient electric power. This system tends to be used increasingly around the world. Moreover, since voltage is high and the power transmission distance can be long, it is advantageous because the number of substations is decreased. Because of this advantage, examples where this system is introduced into long-distance railways, suburban railways, and urban railways are increasing. AC electrification system is studied below.

2) Study of AC Electrification Systems

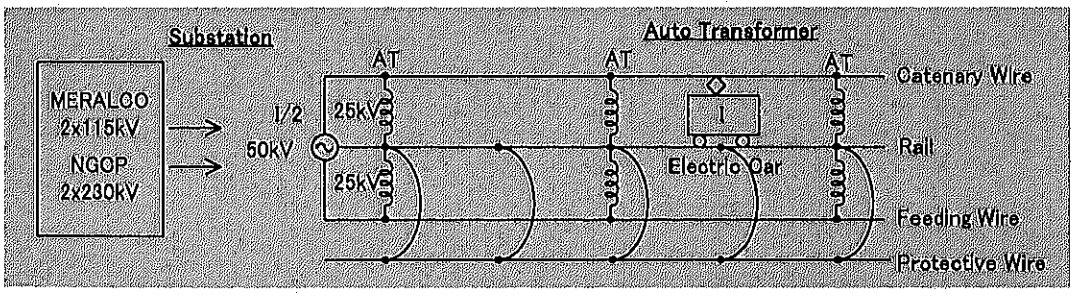
The current is transmitted to the train motor through the overhead contact line and pantograph from the AC substation and returned to the AC substation again through wheels, rails, etc. after consumption. The current returned to the substation is called the return current which has three AC feeding systems of different system configurations.

Table 7.2-5 AC Electrification System Configurations and Characteristics

	System Configurations and Characteristics	Distance between Substations
Direct-Current Feeding System	• The return current back to the substation is through the rails. • Approx. 40% of the return current leaks to the ground from the rails.	Approx. 50km
BT Feeding System	• The return current back to the substation is through the dedicated negative line. • BT (Booster Transformer) is installed at an interval of approx. 4km on the contact wire to boost the return current on the negative line to be equal with the supply and return current. • The leakage current from rails is reduced due to this boosting.	Approx. 30km
AT Feeding System 2x25kV system	• The return current back to the substation is through the dedicated AT feeding line. • The transmission length becomes long in order to transmit electric power with 2x25kV. • An AT (Auto Transformer) is installed at an interval of approx. 10km. It is used to step down 25kV for feeding and to boost the return current. • Shinkansens began operations using the BT feeding system, however, the system was changed to the AT feeding system for improvement. • The AT feeding system for Shinkansens is the standard for the world's high speed railways.	Approx. 70km

Source: JICA Study Team

The AT feeding system is suitable for long distance and high speed railways. In addition, the communication failure due to electromagnetic induction, which occurs when the return current leaks to the ground from the rails and causes damage to communication lines, is improved. Each country installed a different AC feeding system for various reasons. For AER projects, the AT feeding system which has these advantages should be recommended.



Source: JICA Study Team

Figure 7.2-1 AT Feeding (2x25kV) System

3) Proposed AT Feeding (2x25kV) System

In this project, as an AC feeding system, the AT feeding (2x25kV) system is proposed. Two AC substations (SS) equipped with 50MVA transformers are installed at an interval of approximately 50km as shown in Figure 7.2-2. A sectioning post (SP) is installed at the intermediate point and the electric power is supplied up to these posts in ordinary times. Sub sectioning posts (SSP) are installed on the sides of 2 terminal stations, and used for maintenance works or whenever else there is a need to cut the power supply. An SSP is installed at the entrance and exit of underground sections, if needed. Auto transformer posts (ATP) are installed at intervals of approximately 10km. Each feeding lines connects in the SP so that if one of the substations is down the feeding section of an adjacent substation is extended.

The proposed sites of substations are shown in Figure 7.2-3.

a) Receiving Substation

The electric power supplied from the electric power company is received at a dedicated receiving substation and then transmitted to the feeding substation. It is recommended that the receiving and feeding substation be built on the same property. To respond to the power failure of a power supply company, the double receiving system should be adopted as a receiving system.

b) Estimation of Electric Power Requirements

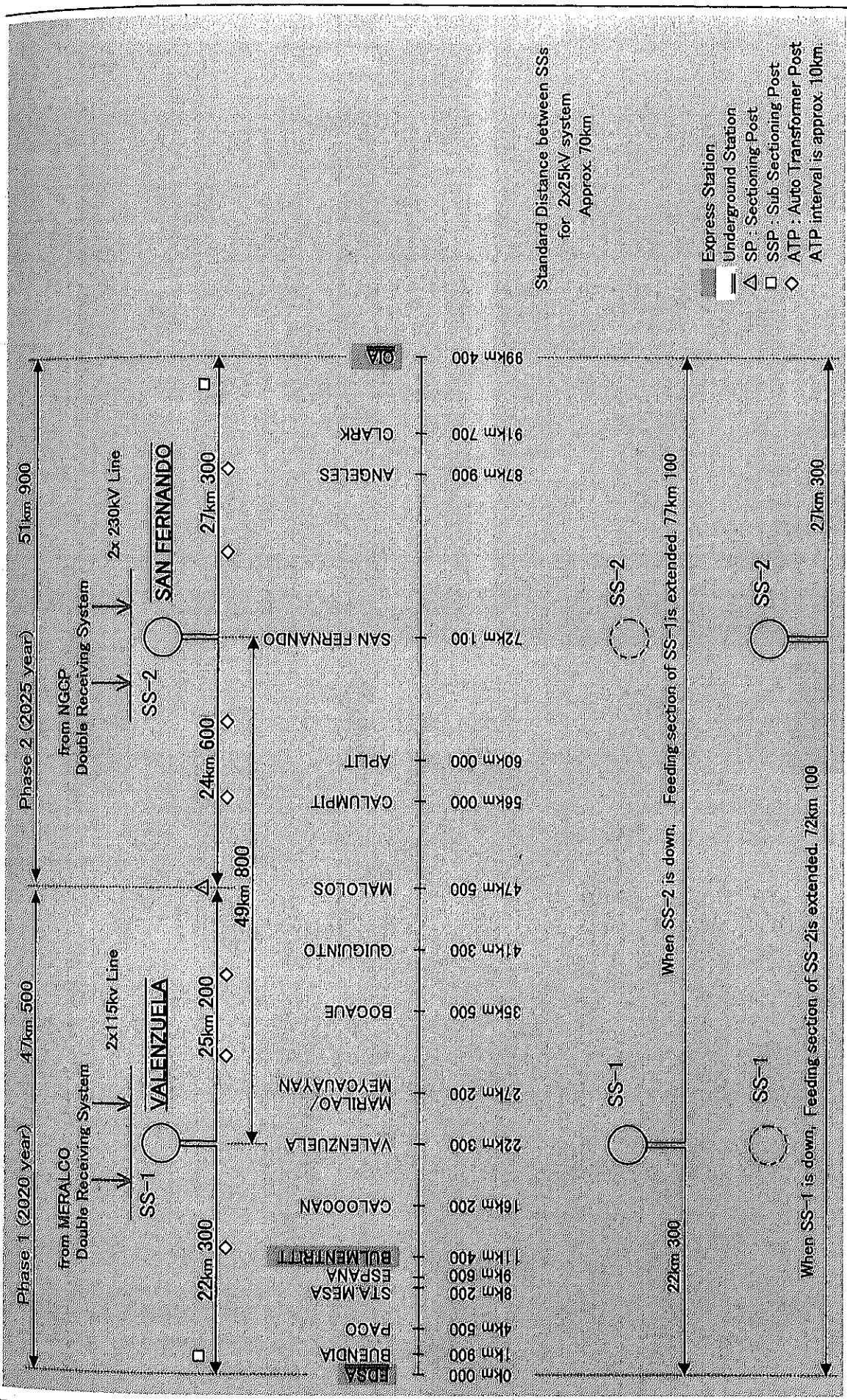
The required electric power for the AER is estimated by approximate calculations. The estimation is calculated from the values of the rate of electric power consumption, the electric power consumption of stations and depots, the peak headway, the number of cars in a train formation, the vehicle weight and the route length.

Table 7.2-6 Required Power Demand (MVA)

	Phase 1 year 2020	Phase 2 year 2025	
	SS-1	SS-1	SS-2
Traction Power	27.6	36.4	39.7
Auxiliary Power	6.1	6.1	3.4
Total Demand	33.7	42.5	43.1

Source: JICA Study Team

SS-1 VALENZUELA Substation
SS-2 SAN FERNAND Substation



Source: JICA Study Team

Figure 7.2-2 Layout of AT Feeding (2x25kV) System

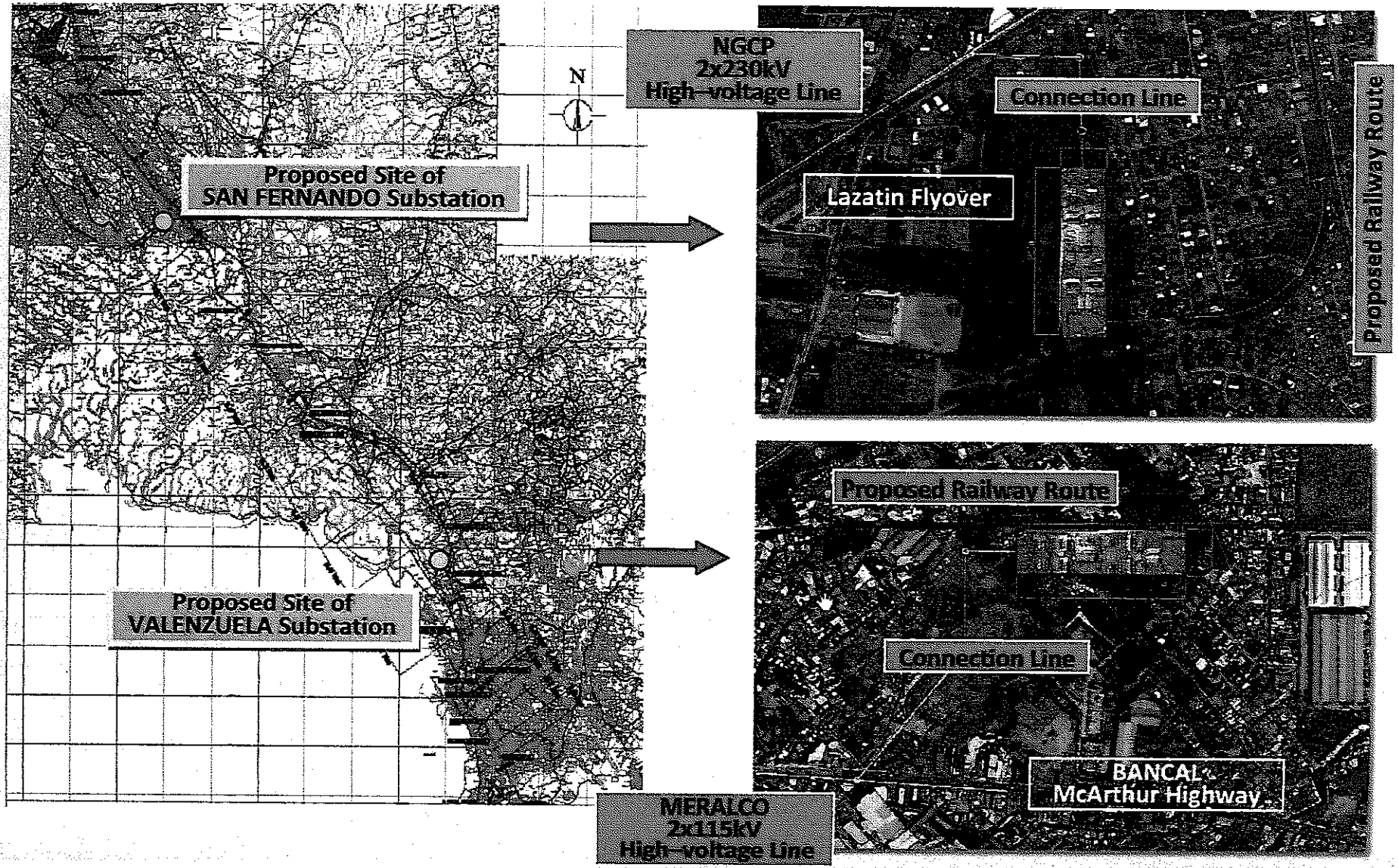


Figure 7.2-3 Proposed Sites of Substations

Source: JICA Study Team

4) Feeding Systems which can cope with High Speed Railway

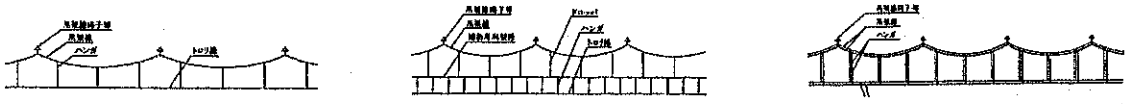
For the AER, the higher operating speed is required. As a reference to selecting the suitable feeding system, examples of the latest feeding systems corresponding to high speed are shown below.

Table 7.2-7 Example of Systems Corresponding to High Speed with Catenary

Catenary type	Range of application	Existing operation speed	Corresponding to high speed in conventional railway	Shinkansen, etc.
Simple catenary	Middle speed Middle capacity	~ Approx. 100km/h	130km/h Japan	
Heavy simple catenary	High speed Middle capacity	~ Approx. 140km/h	160km/h Japan	
Deformation Y shape Simple catenary	High speed Middle capacity	~ Approx. 130km/h		300km/h Germany, Spain 350km/h China
Compound catenary	High speed Large capacity		160km/h Japan	
Heavy compound catenary	High speed Large capacity		140km/h Japan	300km/h Japan, Taiwan 350km/h China
Twin simple catenary	High speed Large capacity	~ Approx. 140km/h	180km/h Japan (Test Run)	
CS Simple catenary	High speed Middle capacity			260km/h Japan
Simple catenary with presag	High speed Middle capacity			300km/h France, Korea

Source: JICA Study Team

From the results shown in the above tables, the heavy simple catenary system, the compound catenary system and the twin simple catenary system are found to be appropriate feeding systems for high speed operation at around 160km/h.



Heavy simple catenary　　Compound catenary　　Twin simple catenary

Source: JREEA

Figure 7.2-4 Proposed Catenary System

7.2.2 Signaling System

1) Basic Scheme of Signaling System

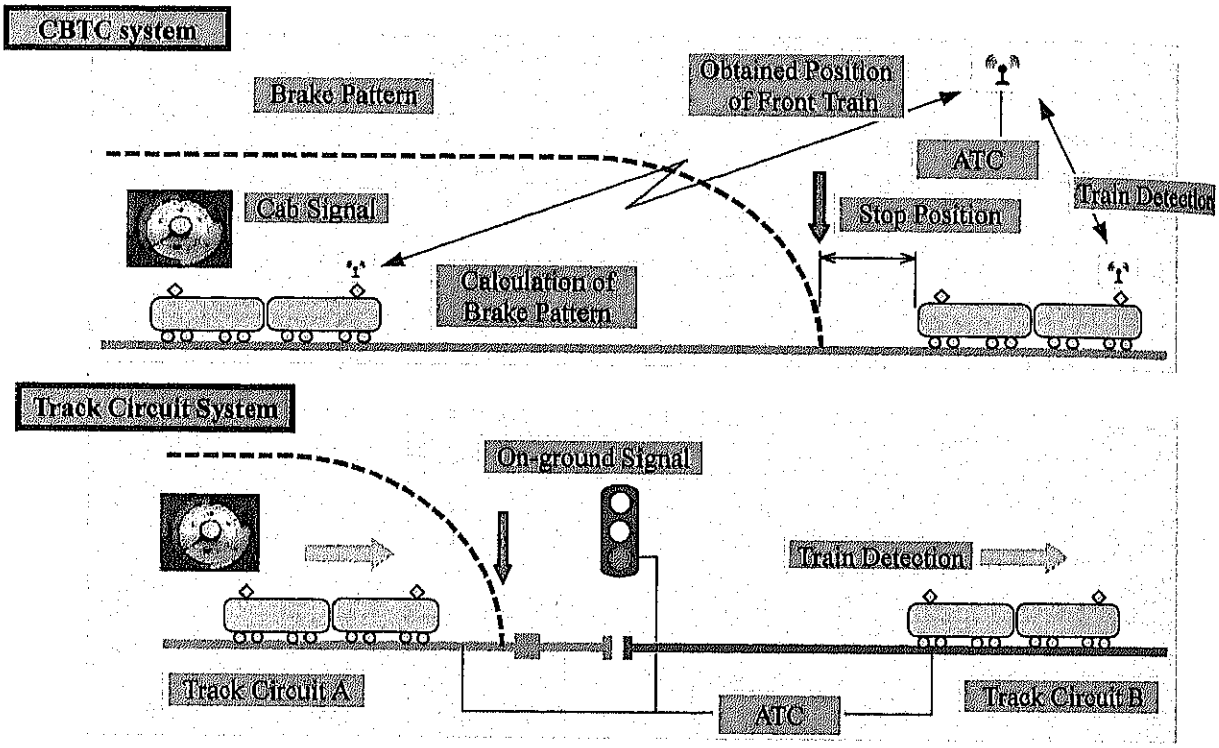
The signaling system of AER is based on the following system.

- Automatic Train Protection system (ATP)
- Centralized Traffic Control system(CTC)
- Automatic Train Operation system (ATO)

- Communication Based Train Control system(CBTC)

2) Recent Signaling System

Many signaling systems using a track circuit have been used in the past, and these signaling systems are reliable. On the other hand, in recent years, a system which uses radio without the track circuit has been introduced widely, and more development is expected in the future. The system configuration and characteristics of the CBTC and the track circuit system are shown in Figure 7.2-5 and Table 7.2-8.



Source: JICA Study Team

Figure 7.2-5 System Configuration of CBTC and Track Circuit System

Table 7.2-8 Characteristics of CBTC and Track Circuit System

	Radio system	Track circuit system
Detection of train	An on board tachogenerator detects the position of the train, and the transponder on the ground adjusts the position information. The other manner to detect position is by radar.	When a train enters the track circuit, the track circuit is shorted by the wheels and the axle of the train. The signaling system recognizes the short and detects the position of the train.
Block system	The train running behind a train can obtain the position of the front train. The train behind can calculate the range so it can be stopped safely. The range is called the moving block.	A fixed block is set up using a continuous track circuit. Simultaneous operation of two or more trains is not allowed in this section.
Speed control	The on board program of the following train calculates a braking pattern from the moving block and the running speed of the train, and controls the running speed automatically.	A signaling system gives a "go", "attention" or "stop" message to signal the fixed block behind the train. And The driver confirms this and controls the running speed of train.
Signal	Cab signaling	Many on-ground signals are used. Cab signaling is used with railways, such as the Metro, the high-speed and high-density operation railways where it is difficult to confirm the on-ground signal by sight.
Transmission of information	Train control information is transmitted to the trains by digital radio via antenna from the radio base. The current position of the train is returned to the radio base from the train.	Track circuit transmits signals, such as control speed, to the train. Moreover, a ground coil transmits an alarm message telling of excess speed, and a transponder transmits the data for brake operation.
ATP	When a driver ignores a stop signal and a running speed is exceeded, the ATP controls the speed or stops the train automatically.	Same as on the left
ATO	Based on an operation pattern between stations, an on board ATO operates the train automatically using an ATO ground coil and the train control device.	Same as on the left
Equipment on ground	Radio base, Antenna, etc. The arrangement is decided by the range of access of an electric wave, and operation density. Power cable is mostly installed along the whole line.	Signals on ground etc. Generally, track circuit, signal cable, and power cable are installed along the whole line.

Source: JICA Study Team

3) Considerations in regard to the Signaling System for AER

To assist in determining whether a CBTC system or a track circuit system will be applied to the AER, the considerations of the each system are shown in Table 7.2-9.

Table 7.2-9 Considerations of Track Circuit System and Radio System

	Radio System	Track Circuit System
Introduction Examples	A few	Many
High-speed Performance	Japan ATACS, COMBAT, SPARCS Europe ETCS China CTCS	Japan Shinkansen
High-density Operation	90 seconds or less, moreover possible to shorten the train interval by moving block.	90 seconds or less
Reliability	It is necessary to secure the channels and frequencies for the railway only.	Proven systems.
Safety	In order to ensure security, data encryptions and soundness checks are needed.	Proven systems.
Maintainability	Maintenance works are reduced, because there is comparatively little ground equipment.	Maintenance of on-ground signals, track circuits, etc. are needed.
Economics	Maintenance is reasonable but construction is costly.	Construction and maintenance are costly.
Flexibility of Block	An antenna can be installed in any position.	The length of a track circuit is from tens of meters to hundreds of meters.
Amount of Transmissions	There are many transmissions by using radio system.	There are a few transmissions from a track circuit.
Detection of Broken Rail	Another manner to detect is needed.	Possible to detect by track circuits.
Length of Train	Suitable for the trains of fixed length. When length differs, it is necessary to input the lengths.	Possible to correspond to trains with different lengths.
Mutual Extension Operation	Construction of ground equipment is comparatively little.	Construction of ground equipment increases considerably.

Source: JICA Study Team

7.2.3 Telecommunications System

1) Optical Fiber Transmission Lines (OFTL)

Optical fiber cables can transfer a far greater amount of information than metal cables. OFTL for railway systems transfer large amounts of information such as trunk radio communications, signaling, passenger information, time signals, power supply management, telephone communications, fare collection information, images and fire prevention information. Optical fiber cables are laid in duplicate, up and down bounds, in order to respond to line failures and equipment outages.

As image data, especially data for monitoring safety on platforms during congested times, is larger than sound information, it is more efficient to use multi-media transmission lines utilizing gigabit Ethernet technology. Furthermore, although Wi-Fi and wireless LAN can be now used in high speed railway cabins, broadband wireless transmissions can be used by connecting LCX cables using a repeater from the OFTL.

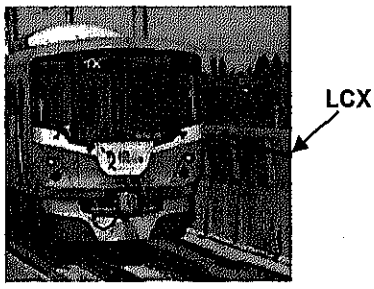
Apart from railway use, railway companies lease OFTL to other companies. The OFTL are sized to provide a large capacity in anticipation of an increase in demand in the future and services to the other companies are provided through the lines not being used by the railway company (Dark fiber).

2) Digital Trunk Radio System

Radio systems are used for communications between train crews and the operation commander since trains are moving objects. The radio system is being updated to a digital radio system that enables various types of data communications from the analog trunk radio system which was based on sound. Recently, digital trunk radio has gained the capability of performing the following functions and this Project utilizes digital trunk radio.

Telecommunications	• Quick check on driver's seat monitor (operation diagram modifications, speed restrictions, etc) • Calling specific trains by the operation commander (multiple lines) • Calling the operation commander by the train crews
Emergencies	• Transmitting emergency security signals from trains, and stoppage instructions for surrounding trains • Emergency interruption from the train crew to the operation commander even if he is on another call • Notification to the operation commander from emergency transmitters on trains and platforms, and power supply suspensions
Maintenance Work Data Transmission	• Communications between workers on a track and all workshops using mobile phones • Providing information to train conductors (status of connecting trains, delays, etc) • Displaying information on LED screens in train cabins (operational information such as accidents and delays) • Transmissions directly to the depot (malfunctioning on-board equipment information)

Communications by digital trunk radio are conducted through Leaky Coaxial Cable (LCX) or multiple above ground antennas. The LCX method, where LCX is positioned at a specific distance close to the train antenna, is a superior method of high quality communication.



Source: JICA Study Team based on JR East

Figure 7.2-6 Digital Trunk Radio by LCX

3) Private Automatic Branch Exchange (PABX)

Exclusive PABX owned by railway companies and telephone lines are used for communications between OCC, stations and workshops in the depots. Through connecting PABX to public communication lines, calls can be made inside and outside the city. Furthermore, PABX enables communications between station staff and users on platforms and concourses. When PABX and telephone lines are planned, the

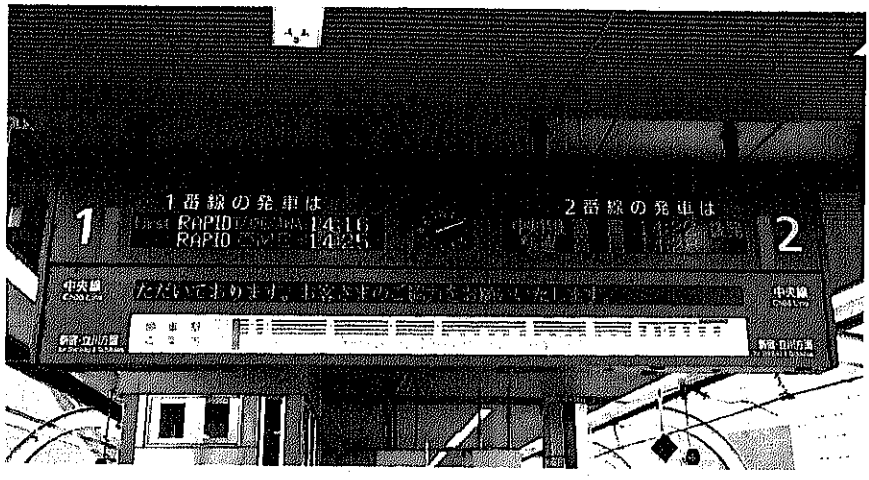
increase of line and capacity in the future should be calculated.

4) Passenger Information Service (PIS)

Station signs such as station name displays, information on boarding trains and exit directions are very important facilities for passengers using stations. They have "easy to understand" universal designs that are created in consideration of not only general users but also the elderly, users with disabilities and tourists from overseas or other regions. Information boards such as station names, gates, transfers and fares are made in consideration of visibility and color sense and displayed with appropriate writing styles, color, contrast and lighting. Moreover, information boards provide guides by navigation blocks (small blocks on the floor used for the visually impaired) and sound and should be installed at a height accessible for wheelchairs and be capable of being operated by voice buttons.

More and more, PIS with LED is being installed in station. Items displayed on the departure display are detailed below.

- Departure — Platform number, Departure time, Departure order
- Train — Train type (commuter, express, etc), Train name, Destination, Prompt of stop station
- Boarding Position — Number of doors, number of cars
- Time — Digital or analog clocks
- Incoming Train — Prompt of incoming train , Current position of incoming train
- Abnormal Operation — Postponements, Delays (cause, possibility of restoration, alternative transportation procedures, etc)



Source: JICA Study Team

Figure 7.2-7 Departure Display

5) Broadcasting Facilities

Broadcasting facilities provide announcements such as incoming trains and closing doors, and promote user safety. Broadcasts are prioritized in the order of microphone broadcasts by station staff, broadcasts regarding incoming trains, broadcasts regarding closing doors.

6) Time Facilities

Time synchronization that shares accurate time is required for time displays at stations, OCC and depots, etc., and time management for AFC, SCADA and CCTV. Master clocks provide an accurate reference time for all clocks, train operation management and passenger information throughout the network.

7) Closed Circuit Television (CCTV)

In order to ensure efficient operations at congested times, it is necessary for station staff and the OCC operation commander to monitor the status of platforms and concourses. Fixed security cameras and remote control cameras are used to perform security checks of station facilities. Fixed cameras are installed so that they cover locations on platforms that are difficult for train attendants to see and television monitors are installed in order to verify the safety of passengers boarding and disembarking from trains from the train attendant's position. Cameras are also installed in important locations such as the OCC, depots and substations, etc., in order to monitor fire prevention measures.

As the advancement of CCTV technology rapidly progresses, enhanced functions such as multiple displays on screens, screen display switching and image storage periods are being added. In addition, broadcasting facilities are provided to conduct notifications and warnings by voice from OCC.

8) Supervisory Control and Data Acquisition (SCADA)

With substations, stations and depots becoming unattended, remote monitoring systems are being implemented from the OCC using remote terminal units. When abnormalities are detected in equipment at substations or depots, concentrated monitoring systems that automatically start protection linked systems are prepared at the OCC.

9) Uninterruptible Power Supply (UPS)

UPS that switches to power supply from a battery and outputs stable current is installed in order to respond to times when power supplied by electric power companies goes down or power faults such as sudden decreases of voltage are detected. Normally, electric power is fed to a battery recharger. Power supply following a power outage continues for four hours or more and a signal system should be introduced to stop the train in a safe location. Furthermore, UPS is used for signal systems and communication systems. However, it is necessary to secure independent signal power and absolutely avoid shared use.

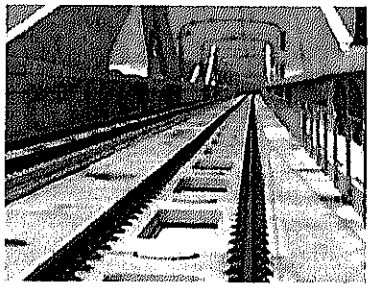
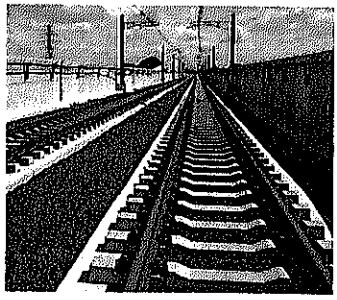
7.2.4 Track Works

1) Selecting of Track

As reference for selecting the track suitable for the AER, Table 7.2-10 shows the comparison of the performance of tracks which have been frequently used recently.

From the results of this comparison table, tracks suitable for the following sections are shown below.

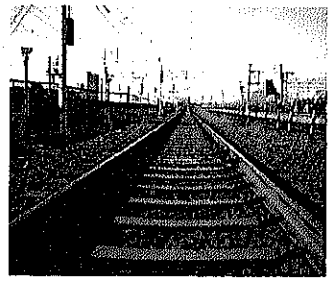
- The elevated section for high speed operation; Slab track
  However, in the residential districts where reduction of noise or vibration is requested, Solid bed track with resilient sleepers, which are excellent in vibration or sound proof ability, should be used.

Source: JICA Study Team

Figure 7.2-8 Elevated section

- The underground section in urban areas; Solid bed track with resilient sleepers
  In the underground section, since the work environment for track maintenance is poor, the low maintenance track which can reduce maintenance work is desirable.
  Moreover, since the vibration of the train running underground may have a negative influence on the buildings at ground level, track which is excellent in vibration proof ability should be used.
- The concrete bridge section in urban areas: Solid bed track with resilient sleepers
  According to the need for soundproofing, ballast etc. is spread to reduce the noise along the surface of the track.
- Depot area; Ballast track on a soil track bed (ballast mat is not required)

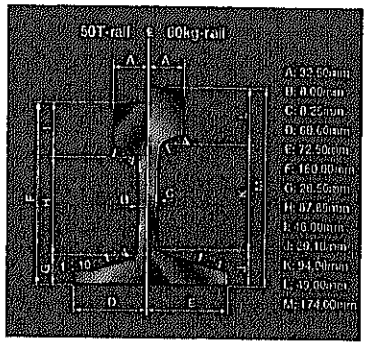
Source: JICA Study Team

Figure 7.2-9 Underground, Bridge Section and Depots

2) Running Rail

Generally speaking, the standard of the running rail is decided with the passing tonnage and maximum running speed of the rolling stock. A running speed of 160km/h is classified as the top grade of a railway line in Japan, so it is desirable that the running rail is Japanese standard 60 kg/m rail equivalent.

Moreover, high speed operation in the curve sections accelerates wear of the running rail. As a countermeasure, the end head hardened rail which has resistance to wear should be used in the curve sections.



Source: JORSA

Figure 7.2-10 Rail Cross Section, 60kg/m Rail Dimensions

3) Turnout for High Speed

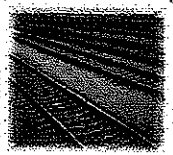
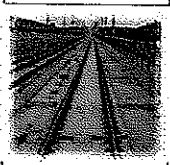
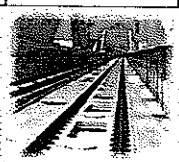
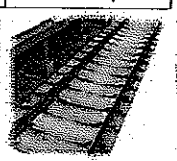
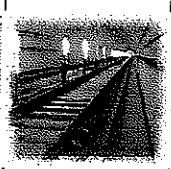
When a train passes on a turnout in the branch direction, the running speed is limited to the speed defined by the turnout angle, so the alignment of the main line designed for high speed operation is desirable for the turnout angle to be as small as possible.

For a solution to this limitation, the No. 38 turnout which can allow a train to pass through the turnout at a 160km/h running speed was developed in Japan. This is actually used in service today and the speed-up of trains has been achieved by this development.

Source: JICA Study Team

Figure 7.2-11 No. 38 Turnout

Table 7.2-10 Comparison of Performance of Tracks

Track type	Ballast track		Slab track		Direct fastened track			
	Ballast track with ballast mat	Ballast track with resilient sleeper	Flat slab track	Frame shaped slab track (with noise reduction ballast if need)	Direct fastened track on concrete bed	Solid bed track with resilient sleepers	Solid bed track with removale resilient sleepers	Solid bed track with removale resilient sleepers (with noise reduction ballast if need)
Photograph								
Application example	Shinkansen (Japan)	Shinkansen (Japan)	Shinkansen (Japan)	Seibi Shinkansen (Japan)	Elevated railway Metro	Elevated railway Metro LRT Line1 NEX	Shinkansen (Japan)	Elevated railway Metro
Low maintenance track	Track with ballast		The low maintenance track without ballast on the track bed					
Displacement of track	Easy to cause		Hard to cause					
Construction cost	1	1.1	1.3	1.2	0.8~1.1	1.5		
Repair and move of track	Possible to move the rails		Change of height by track pad				Change of height by track pad or pad under sleeper	
Replace of sleeper	Available		–		Not available	Available		
Construction process	Ballast laying→Rail unit installation →Ballast tamping (Track adjustment)		Slab carrying in, installation →Rail installation, adjustment		Rail unit installation→Mold installation→Track adjustment →Concrete placing→(Spread of noise reduction ballast)			
Workability	Good		Good		A little poor			
Maintenance work	Constant maintenance work is required.		Maintenance work is reduced substantially.					
Vibration proof Sound proof	Good	Mitigation of vibration by resilient sleeper	Occurrence of noise	Mitigation of noise by ballast	Poor	Good	Good	Mitigation of noise by ballast
High-speed performance	Possible to operate 260km/h	Possible to operate 260km/h	Possible to operate 320km/h	Possible to operate 320km/h	~Approx. 100km/h	Possible to operate 160km/h	Possible to operate 260km/h	Possible to operate 160km/h
Applicability: Viaduct Bridge	Poor	Poor	Good	Excellence		Good	Good	Excellence
Applicability: Shield tunnel			Poor	Poor	Poor	Good	Excellence	Good
Applicability: Depot	Excellence For low speed Without ballast mat							

Source: JICA Study Team

7.2.5 Depot Facilities

1) Number of Train Sets and Cars

The train set formations of the express and the commuter services are shown in Table 7.2-11.

Table 7.2-11 Train Formations

	Services	Cars/train set	Train sets	Cars
Phase 1 Year 2020	Express	0	0	0
	Commuter	10	8	80
	Total		8	80
Phase 2 Year 2025	Express	8	8	64
	Commuter	10	20	200
	Total		28	264
In the future	Express	8	17	136
	Commuter	10	30	300
	Total		47	436

Source: JICA Study Team

2) Depot Plan

Depots for the AER are located at two sites. One site is a main depot with a workshop, and the other site is the satellite depot for train set stabling only. The size of the depot facilities will be determined by 47 train sets with 436 cars in the future which are shown in Table 7.2-8.

3) Inspection and Maintenance Works

Table 7.2-12 shows the outline of inspections, cycle and time required in Japan.

Table 7.2-12 Outline of Inspections, Cycle and Time Required for Electric Passenger Trains

	Type	Outline of inspections	Cycle	Time Required
Periodic Inspection	Daily inspection	Verification of the movement and the mounted status of the main parts at service commencement	3 days	1.5 hrs
	Monthly inspection	Verification of the movement and the function of the main parts, and adjustment of the instruments, etc	3 months	2 days
	Important parts inspection	Overhaul of the main parts, such as the traction motor, the driving system and the brake system, etc	4 years	Approx. 18days
	General inspection	Check, repair and replace as necessary by dismounting and disassembling of all equipment	8 years	Approx. 25days
Maintenance & Repair	Unscheduled repair	Repair of a down or damaged car under service operation Repair of the detected failure parts under inspection	As required	
	Wheel turning	Shaping of the correct profile of the wheel tread using the wheel lathe machine on rail	As designated	
	Car washing	Washing of the car body by the automatic car washing machine with detergent and soft water Cleaning in the car, manual washing of the front and back surfaces of the train set	10 days	Half a day

Source: JICA Study Team

4) Number of Required Tracks for Inspection and Maintenance, etc

It is assumed that the inspection and maintenance of the express and commuter train sets are implemented in the same depot facilities. The number of required tracks for 47 train sets is shown in Table 7.2-13.

Table 7.2-13 Number of Required Tracks for Inspection and Maintenance

Work	Track	Num. of track			Facilities required
		Main Depot	Satellite Depot		
		2020	2025	future	
Inspection	Daily inspection track	(1)	(1)	(1)	Inspection shed, Pit, Platform for access to roof top, Boarding step
	Monthly inspection track	1		1	Inspection workshop
	Important parts inspection General inspection track	1			Repair shed , Bogie drop facility, Roof top and Under floor equipment detaching facility
Unscheduled repair	Unscheduled repair track	1	1		Unscheduled repair shed, Bogie drop facility
Wheel turning	Wheel turning track	1			Wheel turning shed, Wheel lathe machine on rail, Shunting engine, Stabling shed
Car washing	Car washing track	(1)	(1)	(1)	Automatic car washing machine (separate type), Platform for manual car washing
	Air blast of under-floor track	1			Shed for air blast, Pit
Stabling	Stabling track	(6)	(18)	(17)	Stabling of train set
Others	Inspection track of assembled train set	1			Inspection of the assembled train set
	Test track	1			Running test of rolling stock
	Departure and arrival inspection track	1	1		Connection line between the main line and depot
	Drill track	1	1		Shunting of train set
	Stabling track for shunting car	1			With shed
	Track for carrying rolling stock in depot	1			Working space for lift and movement of rolling stock
Base for track and electric works	Stabling track for maintenance cars	1			Stabling of motor cars
		1			Stabling of trolley, rail loading machine and track maintenance car etc
		1			Stabling of electric maintenance car and trolley etc
	Loading and unloading of materials track	1			Materials for track and electric works
	Run-around track for locomotive	1			Shunting of locomotives
	Drill track	1			Shunting of maintenance trains

Note) Values shown in ( ) are the number of stabling train sets.

Source: JICA Study Team

5) Maintenance Facilities in Workshop

The following facilities are provided in the workshop

- Bogie disassembly shop
- Traction motor shop
- Wheel set shop
- Bogie frame shop
- Under floor equipment shop
- Brake parts shop
- Car body shop
- Pantograph shop
- Air conditioning shop
- Bearing shop
- Electric parts shop
- Air valve shop etc
- Warehouse

The inspection and maintenance of the express and commuter train sets is done at the same workshop. In the workshop, parts, spare parts, instruments, repair tools and tools which can be shared should be integrated and used. With regards to parts which are mishandled, these parts should be strictly managed. The assembled train sets shall undergo voltage resistant and performance tests on the inspection track outside the workshop, and then undergo a running test on the test track.

6) Other Facilities

In addition to the maintenance workshop, the following facilities are provided in the main depot.

- Operation control center
- Workshop staff office
- Track, Electric staff office
- Guard gate
- Motor pool for maintenance vehicles
- Motor pool for emergency vehicles
- Car parking
- Warehouse
- Substation
- Waste water treatment facility
- Pump house
- Hazardous material storage
- Oil warehouse
- Gas bombe storage
- Waste material storage
- Garbage storage

7.2.6 Automatic Fare Collection System (AFC)

1) Outline of the AFC System

AFC systems have been installed in many urban railways around the world and consist of ticket vending machines (TVM), automatic gates (AG), automatic fare adjustment machines, data collecting machines and office booking machines. The summary and installation concept of AFC equipment are described below.

a) TVM

TVM is used for ticket selling and is a machine which automatically issues tickets by passengers paying money and choosing ticket types. TVM which is operated by the passengers is required to be simple and easy to use.

b) AG

AG, which is installed at ticket gates or ticket collection gates, is a machine to rapidly and accurately read

or collect tickets on behalf of station staff. The types of AGs are for entrance only, exit only and both entrance and exit. On entrance, the AG reads necessary information from a card or ticket and writes the entrance record onto it. On exit, the card is again passed over the card reader. At this time the fare is adjusted and confirmed based on the entrance record. If required information is not obtained on entrance or exit, the gate will be closed and the information will be confirmed by station staff.

c) Automatic Fare Adjustment Machines

A fare adjustment machine is installed inside ticket gates and used by passenger themselves for fare adjustment such as excess fare. The fare machine reads the ticket information when the ticket is inserted into the machine. At this time, the fare is deducted from the remaining balance on the ticket and balance due is displayed. After inserting the necessary amount of money, the adjusted-fare ticket will be dispensed, with which the passenger can pass through the AG.

d) Data Collecting Machines

A data collecting machine is a piece of equipment to collect and save daily data from the AFC system such as AGs, TVMs and fare adjustment machines, etc. The aggregated data is transferred to the data management department through online communication facilities. The data is also transferred from this department to the administration department and used for administrative strategic planning and the improvement of passenger services.

e) Ticket Checker

A ticket checker is installed in an information counter next to the fare gates. Recorded information on the card or ticket, such as entrance record, exit record, fare adjustment record, is checked and updated by a station staff member.

2) Estimated Number of AFC System Equipment

The required number of TVMs, AGs and automatic fare adjustment machines are obtained from the following equation.

$$N = P \times C / T$$

Where;

N: Number of Required machines (unit)

P: Number of passengers using equipment at peak 1 hour (person/hour)

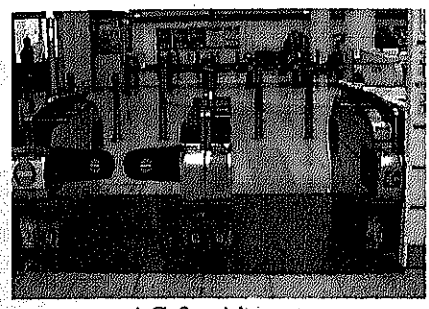
C: Fluctuation ratio of passengers (events or transfer from/to other transportation modes)

T: Performance of machines per unit per hour (person/unit/hour)

3) Considerations for the AFC Installation

- AGs shall correspond to a contactless IC ticket or card.

- The process performance of AGs assumes that the maximum rate is approximately 60 persons per minute.
- Basically, TVMs shall be installed for ticket sales. However, tickets shall be temporally sold by both station staff at the ticket counter and TVMs depending on the situation of banknote and coin circulation.
- For Commuter and Express trains, two different types of TVMs shall be installed.
- TVMs which have functions to choose train services and to reserve a seat shall be installed in Express stations.
- Every station shall have ticket gates that are wheelchair accessible, generally located next to the information counter. The passage width shall be approx. 90 cm.
- Every station shall have ticket gates that are wheelchair accessible, generally located next to the information counter. The passage width shall be approx. 90 cm.
- CIA station shall have AGs which are able to pass suitcases. The passage width shall be approx. 120 cm.
- TVMs and fare adjustment machines shall be designed to be operated easily by wheelchair users, and be equipped with Braille display and brightness adjustment, etc. for visually impaired people.
- This AFC system is integrated in the common ticket system in Metro Manila



AG for Airport

AG for Wheelchair
(at far right)

TVM for Express

Source: JICA Study Team

Figure 7.2-12 AFC Facilities

7.2.7 Platform Screen Door System (PSD)

1) Outline of PSD

PSD is installed for the purpose of accident prevention and environmental improvement as mentioned below.

(Accident Prevention on Platform)
- Preventing accidental contact with a train
- Preventing passengers falling on tracks
- Preventing accidental falls of a drunken person
- Preventing suicide attempts
- Preventing an accident by pushing

(Environmental Improvement of Platform)
- Barrier-free design
- Preventing loss of air conditioning effect
- Blocking train wind
- Reduction of noise

There are two types of PSD and the characteristics of each type are as follows.

- Full height type — This is called a full screen type. There are full-closed types, where the platform is fully covered to ceiling and semi-closed types, where there is a

space between the upper part of the screen doors and the ceiling. The full-closed type improves air conditioning effect of the platform. The cost is the most expensive PSD system and the installation could be difficult depending on ceiling structure.

- Half height type: This is called a movable platform fence. The cost is cheaper than the full height type. Therefore, the installation has been increasing on existing lines which operate driver-only trains or for the purpose of safety enhancement, etc.

In addition, although not a PSD, there is a platform fence which has the same functions as the PSD.

- Platform fence: These are iron fences which are opened around train doors only. The cost is the cheapest.

The door opening/closing is controlled by exchanging commands for opening and closing doors between track-mounted beacons and PSD control units which are installed on the train and platform. To prevent a passenger being left between two doors, train doors are opened after PSDs are opened. Moreover, train doors are closed after PSDs are closed.

Full height type

Half height type

Platform fence

Source: JICA Study Team

Figure 7.2-13 PSD Facilities

2) Considerations for the PSD Installation

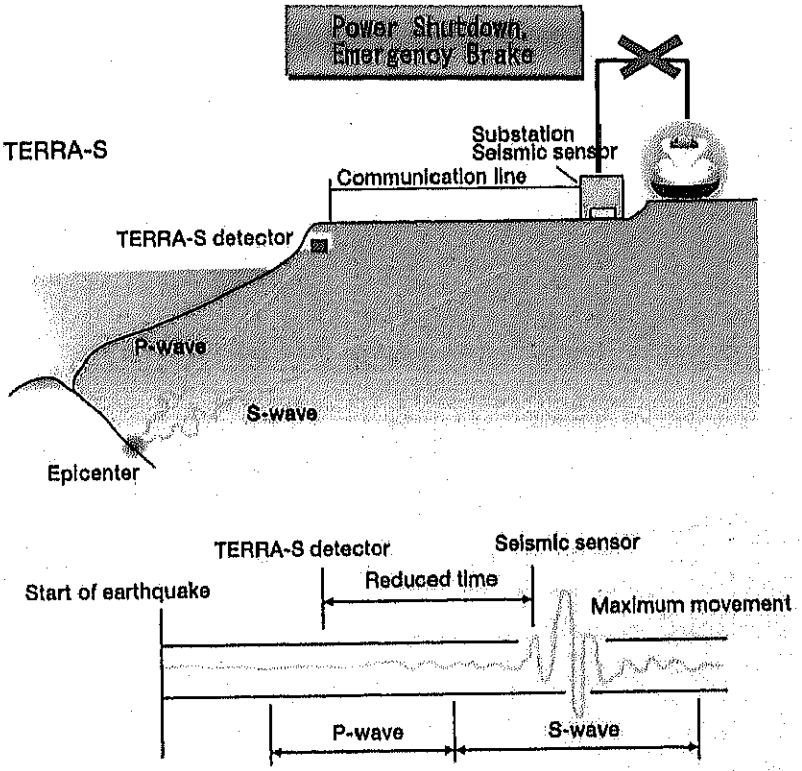
- It is considered that PSDs would be phased in assuming the maximum number of people on the platform at peak time.
- Since the PSD door is installed in a defined position, it is necessary that the door position of all the trains is uniform.
- It is desirable to introduce ATO system and an accurate station stopping system.
- PSD shall be installed at stations where express trains do not stop and on platforms where inbound and outbound express trains pass through.

7.2.8 Early Earthquake Detection System

According to the study "Earthquake Impact Reduction Study for Metropolitan Manila, Republic of the Philippines, 2004" implemented by JICA, Metropolitan Manila would suffer a great deal of damage

because of a magnitude 7 earthquake given the earthquake scenario of the west valley fault. It is said that the magnitude 7 earthquake would cause damage within a distance of about 100km from the epicenter. In that case, most of the planned route area could be affected. Therefore, it is necessary to use earthquake resistant structures and to stop trains by using an earthquake detection system before the occurrence of an earthquake.

The process flow and functions of the earthquake detection system of the Shinkansen are as follows. In the case of the Great East Japan Earthquake of 2011, the damage to the Shinkansen facilities was minor because of the earthquake resistant structure and there were no passenger injuries because the Shinkansen stopped safety because of the earthquake detection system.



Source: JORSA

Figure 7.2-14 Early Earthquake Detection System for Shinkansen

- Seismic waves (P-wave, S-wave) are detected by seismometers which are installed in coastal areas and along a main line.
- Electric power is shut down by the system in a substation and catenaries are powered down. Then, the train stops as quickly as possible by operating the emergency brake.
- Due to the shortening of delivery time of the earthquake warning message of the P-wave seismometer and the operation time of the emergency brake, the time to emergency train stop is shortened by 2 seconds.

Regarding considerations for the earthquake detection system plan,

- The detection system shall be enabled to emergency stop all trains in conjunction with other railway routes of Metropolitan Manila.

7.3 Relevant Existing Standards

7.3.1 Rolling Stock

The railway line in this project is planned to be newly constructed and independent from other existing railways. It is possible that the standards applied in the line are unique to this project.

Moreover a variety of used railway vehicles, which were originally used in Japan, are operated on PNR lines at the moment. Therefore there is no problem in applying Japanese regulations and Japanese standards, Japanese Industrial Standard (JIS).

Rolling stock plan in this project could be studied on the basis of Japanese standards.

7.3.2 Civil

Civil structural standards for railways in Japan are shown below.

Table 7.3-1 Standards for Civil Structure

Standard Name	Publication
Design Standards For Railway Structures and Commentary【Concrete Structures】	2004.4
Design Standards For Railway Structures and Commentary【Foundation Structures】	2012.1
Design Standards For Railway Structures and Commentary【Retaining wall Structures】	2012. 1
Design Standards For Railway Structures and Commentary【Earth Structures】	2007. 1
Design Standards For Railway Structures and Commentary【Seismic Design】	2012. 9
Design Standards For Railway Structures and Commentary【Displacement Limits】	2006. 2
Design Standards For Railway Structures and Commentary【Steel Structures】	2009.7
Design Standards For Railway Structures and Commentary【Steel-Concrete Hybrid Structures】	2002.12
Design Standards For Railway Structures and Commentary【Cut and Cover Tunnel】	2001. 3
Design Standards For Railway Structures and Commentary【Shield Tunnel】	2002.12
Design Standards For Railway Structures and Commentary【Urban Mountain Tunnel】	2002. 5
Design Standards For Railway Structures and Commentary【Track Structures】	2012. 1
Maintenance Standards for Railway Structures and Commentary	2007. 1

Source: JICA Study Team

The above standards were published by the Railway Technical Research Institute and supervised by the Railway Bureau of the Ministry of Land, Infrastructure and Transportation of Japan,

Also "Standard Specifications for Tunneling 2006: Shield Tunnel" was published in 2007 by Japan Society of Civil Engineers in English.

Limited design method and performance design method are applied for design of civil structures without Shield Tunnel.

7.4 Maintenance

7.4.1 Rolling Stock

The rolling stock to be used in this project will be of modern technology. However the reliability, availability and durability of the new rolling stock will depend not only on its original capability but also mainly on maintenance. The maintenance system is usually presented by the rolling stock supplier because it is in tight connection with its design policy.

Basically, Planned Preventive Maintenance is applied to rolling stock maintenance because an accident involving rolling stock might cause a fatality and even a trivial failure would affect widespread disruption to traffic. The maintenance system and period are modified according to the progress of technology. A Typical Planned Preventive Maintenance system in Japan is shown as an example in Table 7.4-1.

Table 7.4-1 Typical Maintenance System in Japan

Type	Periodicity	duration	Contents of work	Site
Operational Inspection	Every 2-6 days	1 hour	• External visual examination • Visual examination and functional verification of roof mounted electric equipment, brakes, doors and driving controls • Oil & Grease	Depot
Functional Maintenance	Every 90 days or 30,000 km	1 day	• Inspection of pantographs, traction circuit, driving unit, brakes and doors • Inspection of body condition • Inspection of function and insulation of electrical components • Ultrasonic axel inspection, not every time • Lathing wheel profile as required	Depot
Major Equipment Maintenance	Every 4 years or 600,000 km	10 days	• Removal, disassembly and detailed inspection of traction motors, power transmission units, driving units and braking unit • Bogie replacement	Workshop
General Inspection	Every 8 years or 1,200,000 km	2 weeks	• Removal, disassembly and detailed inspection of traction motors, power transmission units, driving units and braking units • Replacement of certain major components, depending on condition • Bogie replacement • Interior passenger accommodation overhaul • Car body repair and re-painting as required	Workshop

Source: JICA Study Team

7.4.2 E&M System

1) Maintenance of Track

In order to secure track performance, the following inspection is carried out at regular intervals.

- Measuring the track displacements and swaying motions of train, and checking the status of the track.
- Checking the strength of components such as rails and sleepers and their functionality.

As the track maintenance standard for ensuring safe train operation and a comfortable ride, Japan Railways (JR) group defines the targeted values as shown in Table 7.4-2.

Table 7.4-2 Acceptable Targeted Values for Rail Maintenance

		Operation at 120km/h or more
Irregularity of rail gauge	Spreading or narrowing of rail gauge	+6mm,-4mm
Irregularity of cross level	Tilt of 2 rails	7mm
Irregularity of longitudinal level	Concavity and convexity in rail vertical direction	7mm
Irregularity of alignment	Concavity and convexity in rail horizontal direction	7mm

Source: JICA Study Team

By the Japanese laws and regulations, the period of scheduled inspections for track are shown in Table 7.4-3.

Table 7.4-3 Period of Scheduled Inspections (Track)

		Period of inspection
Conventional railway	Track	1 year after a previous inspection, implementation for less than 1 month
Shinkansen	Track (Inspection of rail gauge, cross level, longitudinal level and alignment)	2 months after a previous inspection, implementation for less than 1 month
	Track (others)	1 year after a previous inspection, implementation for less than 1 month

Source: JICA Study Team

2) Maintenance of Electric Power Facilities

By the Japanese laws and regulations, the scheduled inspections of power equipment should be implemented for every period which does not exceed the period shown in Table 7.4-4 according to equipment.

Table 7.4-4 Scheduled Inspection (Power Supply Facilities)

Electric Power Facilities Equipment			Period
Conventional railway	OHC	Trolley lines, catenary lines and components of OHC	1 year
	Feeding line for traction power	Overhead power transmission lines, Power cables	
	Protective device	Disconnect switch for feeding power, Power switchboard	
	Transformer	Traction transformer, Rectifier	
	Power supply instruments other than listed above		2years

Source: JICA Study Team

3) Maintenance of Signaling Facilities

As mentioned above, the scheduled inspections of signaling equipment should be implemented by the period shown in Table 7.4-5.

Table 7.4-5 Scheduled Inspections (Signaling Facilities)

Signalling Facilities Equipment		Period
Conventional railway	Block equipment	1 year
	Automatic train protect	
	Signaling equipment on the ground	
	Interlocking device, points	
	Automatic train stop, automatic train control	
	Track circuit	
	Crossing facilities	
	Centralized traffic control, automatic route control, programmed route control, programmed traffic control	2 years
	Automatic train operation	
	Telecommunications equipment and lines for signaling system	

Source: JICA Study Team

7.4.3 Civil Structures

In Japan, technical standard for maintenance for railway structure, namely "Maintenance Standards for Railway Structures and Commentary of Japan" (hereinafter referred to as the "maintenance standard"), is established by Railway Technical Research Institute (RTRI)[1].

It is composed of five volumes for various types of railway structures. Five types of structures covered by these standards are concrete structures, steel and composite structures, foundations and retaining structures, earth structures (embankments and cutting) and tunnels.

Summary of the maintenance standard is as shown below:

[1] *Maintenance Standards for Railway Structures and Commentary: Railway Technical Research Institute, March 2007*

1) Verification of Performance and Judgment of Soundness

Performance is verified by judging soundness. It is prescribed that soundness be judged, in principle, by providing appropriate judgment categories based on the results of determined deterioration causes and prediction of deterioration.

Table 7.4-6 shows standard judgment soundness. This table shows that prescriptions are established, in principle, in consideration of the characteristics of each structure.

Judgment of soundness in general inspections and extraordinary inspections is generally categorized into ranks A, B, C, and S (shown in Table 5) based on survey results. However, when a state thought to cause a hazard in normal train operation is found, the rank is judged as AA, and measures such as stopping trains shall be taken. The rank is also judged to be AA when spalling of concrete fragments threatens public safety, and countermeasures such as immediately knocking down loose concrete fragments, and prohibiting entry underneath viaducts must be devised in this instance.

As for individual inspections, if the state of the structure is judged as rank A in the general inspection and/or extraordinary inspection, identification of the causes of deterioration, and prediction of deterioration are conducted. Judgment of soundness is also furtherer sub-categorized into A1 and A2.

Table 7.4-6 Judgment of Structure State and Standard Soundness

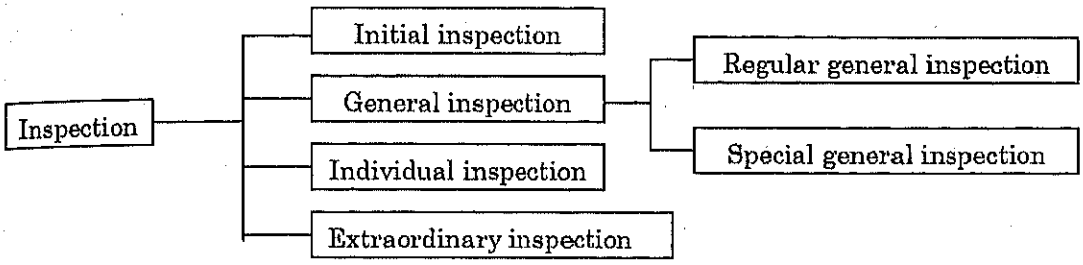
Soundness		Structure State
A		State that threatens operational safety, safety of passengers, public safety, guarantee of regular train operation, or deterioration that might cause this state
	AA	Deterioration that threatens operational safety, safety of passengers, public safety, or the guarantee of regular train operation, and which require emergency countermeasures
	A1	Progressive deterioration that causes the performance of structures to drop, or heavy rain, floods, or earthquakes that might impair the performance of structures
	A2	Deterioration that might cause a future performance drop of structures
B		Deterioration that might result in a future soundness rank of A
C		Slight deterioration
S		Sound

Note: Soundness ranks A1 and A2, and soundness B, C and S may be categorized by individual railway operators in consideration of the actual inspection circumstances.

Source: RTRI

2) Inspections

Figure 7.4-1 shows inspection categories for structures.



Source: RTRI

Figure 7.4-1 Inspection Categories for Structures

a) Initial Inspection

Initial inspection covers new structures and reconstructed/replaces structures, and is preformed for the purpose of ascertaining the initial state of the structure. Initial inspection should also be performed as necessary when large-scale repair/strengthening has been made.

b) General Inspections

The maintenance standard categorizes general inspection into two categories, regular general inspection and special general inspection.

Regular general inspection is performed mainly to detect deterioration to the structures. Special general inspection is performed mainly to improve accuracy in judging soundness.

c) Individual Inspection

Individual inspection is performed for the purpose of judging soundness with high accuracy in structures where deterioration has occurred or might occur.

Individual inspection is performed on deterioration judged as soundness A in general inspection and extraordinary inspection to reliably ascertain the state of that deterioration and to perform higher accuracy judgment of soundness. Even when attempting to extend the inspection interval by special general inspection through survey, methods for determining the causes of deterioration and predicting deterioration shall conform to the provisions of individual inspection. When the life cycle cost is taken into consideration, even for structures with integrity of B to S, the concept of preventive maintenance is also sometimes important and countermeasures should be taken for predicted deterioration. Even for such purposes, judgment of soundness and selection of countermeasures should be conducted in compliance with the provisions of individual inspections.

d) Extraordinary Inspection.

When deterioration has occurred in a structure, track, or overhead catenaries due to earthquakes, heavy rain or automobile collisions, restriction of service (e.g. suspension or slow down of train operation) are generally placed in accordance with the operation control manual stipulated by the railway operator. The

following prescribes inspection, judgment criteria, and countermeasures to be performed to judge whether or not the restriction of service (suspension or slowing down) should be continued before performing individual inspection.

Inspections for structures that are performed non-periodically include roundup or blanked inspections performed when an earthquake or other disaster has occurred, and when deterioration has been discovered on similar structures, and inspection of locations where are public disaster is feared due to concrete spalling. These inspections also are included and handled within the scope of extraordinary inspections.

3) Countermeasures

"Countermeasures" prescribes items relating to countermeasure methods, timing, type, monitoring methods, repairs/strengthening, restriction of service of structures, reconstruction/replacement, and handling after countermeasures.

Some countermeasures will be performed based on the soundness judgment category. These methods are

a) monitoring,

b) repair/strengthening,

c) restriction of service,

d) reconstruction/replacement.

One or a combination of these is selected. Of course, in selecting the countermeasure, the soundness, importance, constructability, economy, and other factors of the structure are taken into consideration.

CHAPTER 8

PROCUREMENT AND CONSTRUCTION PLAN

CHAPTER 8 PROCUREMENT AND CONSTRUCTION PLAN

8.1 Railway Operation Schemes

8.1.1 Implementation Schemes of Operation & Maintenance

This section describes the most common approaches to implement the Operation & Maintenance (O&M) of a railway system. For purposes of easy understanding, and as different operation schemes could have in turn different maintenances approaches, the description is done separately for the operation and maintenance aspects of the functions of an owner/operator.

This section is further subdivided into 3 subsections that first describe the most common schemes, then evaluate them, and finally propose the most suitable scheme for the Manila – Clark Airport Express Railway (AER).

It should be worth mentioned that like the most appropriate funding/implementation scheme (ODA, PPP, etc.), the final and most suitable O&M scheme will be only known after more detailed financial studies are completed, where a detailed cash-flow analysis is available to make the proper decision. Therefore, the schemes presented herewith are based on assumptions of how a plausible PPP scheme will be implemented, and on previous experiences on O&M schemes in other Asian countries.

8.1.1.1 Alternative Operation & Maintenance (O&M) Schemes

1) Operation Approach

The railway businesses, in general, since its expansion of the industry in 19th century, have been developing from the railway core operations with its strong expertise on the railway engineering as well as the operational supervision, evaluation, management and control activities, then dealing with travel comfort and pleasure, safety and security, environment, and further onto the IT based ticketing, fare collection and settlement system serving also as a managerial information tool. This can be illustrated as the vertical and horizontal integration process of a railway institution.

The railway industry around the world, however, has been introducing re-organizing or re-shaping to introduce a more effective operations and a clear responsibilities among different types of operations. Some auxiliary services such as the rolling stock and station clean-up, station security, ticketing, IT services are outsourced. Holding company options have been used when a railway has a few lines and/or its business has a wide range of activities.

Those vertical and horizontal disintegrations are considered as a way to make clear the responsibilities of each activity and at the same time to aim more effective operations. One should note as the key feature in those cases that the railway companies always keep their main operations and their management under their direct control and thus they maintain their institutional capacity within the organization.

Furthermore, air and shipping transportation industries where companies operate in a very competitive market, they have been introducing outsourcing some of the activities to dedicated service companies. Some cases are found in airplane cabin or vessel crew on board, security staff, IT development staff is dispatched under the outsourcing contracts.

Given the above future operation modality, possible type of contract for the implementation of AER would be, i) Operation and Maintenance Concession under PPP Net Cost Scheme, ii) Operation and Maintenance Concession under PPP Gross Cost Scheme, iii) ODA including O&M Concession iv) Direct

Operation and Contracting Maintenance, v) Direct Operation and Direct Maintenance, and vi) Direct Operations with Contractual and Outsourcing as illustrated in the following table. Table 8.1.1 below describes these types of contracts.

For purposes of convention, in the Table 8.1.1 the Government is the Public party of the PPP, and Concessionaire to the Private party of the PPP scheme.

Table 8.1-1 Type of Contract

Type of Contract	Definition
i) Concession O&M (PPP Net Cost) Hybrid: Gov.:civil; private: E&M + rolling stock	The government manages civil infrastructure delivery using private sector contractors; government engages the private sector to provide electrical and mechanical (E&M) assets and trains and to undertake operation and maintenance (O&M) through a concession; The government leases civil infrastructure to the concessionaire; The government sets safety standards and fare structure; The concessionaire determines services to be provided and retains fare and other revenue, in which; and additional payments may need to be made by the government to the concessionaire to cover revenue shortfall, or the reverse if revenue exceeds costs; This type is applicable when using PPP scheme such as BOT for E&M portion and BLT for infrastructure.
ii) Concession O&M (PPP Gross Cost) Hybrid: Gov.: civil; private: E&M + rolling stock	The government builds civil infrastructure delivery using private sector contractors; The government engages the private sector to provide E&M and trains and to undertake O&M through a concession; government sets safety and service standards, service levels, and fare structure and level; The government pays the concessionaire an amount equal to the costs the concessionaire incurs in providing agreed services as established through a competitive, quality-based tender; and The government retains all fare revenue; Same as above, this type is applicable when using PPP scheme such as BOT for E&M portion and BLT for infrastructure.
iii) ODA Implementation + Concession O&M Leasing (PPP Net Cost)	The government builds entire infrastructure delivery using private sector contractors; The government provides civil, E&M and rolling stock and engages the private sector to undertake O&M through a concession; government sets safety and service standards, service levels, and fare structure and level; and The concessionaire retains all fare revenue; This type is applicable when using ODA or own funds to finance the project and outsourcing maintenance.
iv) Direct O & Contract M	The government builds civil infrastructure and E&M systems using private sector contractors using ODA or own funds; The government engages in overall operation activities by their own staffing; The government contracts with external entity to provide maintenance services;
v) Direct O&M	The government builds civil infrastructure and E&M systems using private sector contractors using ODA or own funds; The government engages in overall operation and maintenance activities by their own staffing;
vi) Direct Operations with Contractual and Outsourcing	The government builds civil infrastructure and E&M systems using private sector contractors using ODA or own funds; The government engages in overall operation activities by their own staffing for core operations but some non-core operations are contracted out or outsourced; The government contracts with external entity to provide maintenance and other railway related services;

Source: JICA Study Team

2) Maintenance Schemes

General

Maintenance management is a concept which integrates all the activities of maintaining and controlling rolling stock and other facilities ranging from commissioning to heavy repair.

In order to maximize the effectiveness and productivity of the system as a whole, a planned but also corrective maintenance policy is required. The primary aim is the prevention of faults that arise with a view to restoring the items concerned to their former condition as quickly as possible at any time. Maintenance involves carrying out the functions of inspection, servicing and repair.

To achieve optimum efficiency of maintenance efforts, maintenance philosophy and planning should not only consider the previous and present condition of the items concerned, but also their future expectancy and life cycle and the economic aspects of maintenance. Early failures, unexpected failures and failures due to wear and tear can also occur within the life cycle of any individual component. Each of the above problems must be approached in a different manner.

The **Maintenance Philosophy** for the AER must therefore not only provide for preventive maintenance, but also for predictive maintenance and to a certain extent trouble-shooting maintenance in respect of specific items. The aim will be that the operation of the rolling stock and other facilities provided, will be safe and the service and maintenance of all facilities and rolling stock will be carried out accurately so as to extend their life to a point economically and physically justified.

This section describes the general maintenance alternative schemes available for the AER. There are, however, only two basic schemes for maintenance, to wit:

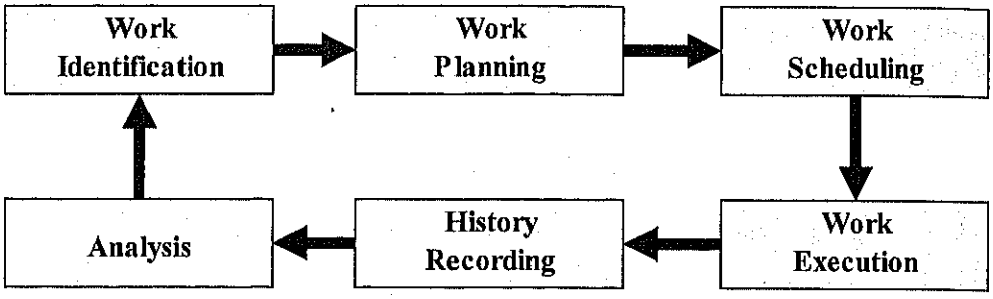
- Direct Maintenance (by Owner/Operator)
- Outsource Maintenance (by third party contractor)

As its name indicates, Direct Maintenance is the scheme where the Owner/Operator carries out the maintenance activities with an in-house work force. This scheme is self-explained, and does not require further elaborate description. Outsourced maintenance, on the other hand, has different options for the degree and tasks to be outsourced. The section below describes those options.

Maintenance Outsourcing Schemes

An important consideration in making the maintenance outsourcing decision is what aspects of maintenance to outsource. If we consider the maintenance management process as consisting of six major steps, as shown in **Figure 8.1.1** below, then a number of options exist.

World Class Maintenance Management System



Source: JICA Study Team

Figure 8.1-1 Maintenance Task Work Flow

In the first instance, organizations may choose simply to outsource the work execution step, while retaining the remaining steps in-house. This is often done on a limited basis, for example, when employing contractors to supplement an in-house work force during times of high workload. This is the minimalist approach to outsourcing.

An alternative approach is to outsource all of the above activities with the exception of the analysis and work identification steps. In this approach, the contractor is permitted to plan and schedule his own work, and decide ***how*** and ***when*** work is to be done, but the outsourcing organization retains control over ***what*** is to be done.

A third approach is to outsource all of the above steps, thus giving control over the development of equipment maintenance strategies (i.e. Preventive and Predictive Maintenance programs) to the contractor. In this instance, the contract must be structured around the achievement of desired outcomes in terms of equipment performance, with the contractor being given latitude to achieve this to the best of his ability. There are advantages and disadvantages to each approach, and the most appropriate approach will depend on the client's particular situation.

Accordingly, outsourcing needs to be well targeted and framed by properly worded contracts. When outsourcing railway maintenance there are two contractual strategies to follow: i) functional requirements, and ii) job specific requirements. As stated in paragraphs above, variations of the two do exist and it is also possible to choose a mixture.

Contracts based on functional requirements, also known as Key Performance Indicators (KPI), are typically related, for example, to track quality, track availability, rolling stock availability, AFC availability, etc. A price for the contract is negotiated prior to the implementation of the contract, bonuses and penalties are used if performance is better, or worse than agreed upon. The time horizon for contracts could be 5 to 10 years, but also longer depending on investment.

Contracts based on job specification requirements are for example rail grinding, tamping, inspection and revision of signaling system, station equipment repair, etc. Typical time horizon is short, equal to the duration of the job.

Looking at how maintenance fits into the wider asset management strategy of an organization also raises interesting challenges.

For example, one challenge that needs to be met is how the maintenance contractors will interface with the railway operators, and the relative responsibilities and duties of each party. Many organizations today are adopting Total Productive Maintenance principles, which encourage operators to take a higher level of

responsibility for equipment performance, and also encourage them to perform many minor maintenance tasks. There is also a growing realization that the manner in which equipment is operated can have a huge bearing on maintenance costs and the maintenance activities required to be performed if equipment performance targets are to be met. A high level of teamwork between the Maintenance contractors and the railway operators is, therefore, vital to the successful completion of the contract. This leads to the view that an alternative, and possibly better, approach to the outsourcing of maintenance is to include operation in the scope of the contract. Hence, the letting of Operations and Maintenance contracts.

Finally, taking things one step further again, there is also a growing realization that maintenance is limited in achieving higher equipment performance by the fundamental design of the equipment being maintained. The best that maintenance can achieve is the inherent reliability and performance of the equipment that is built in by design. There is, therefore, a school of thought that says that the best way to overcome this limitation, in an outsourcing environment, is to also give the contractor responsibility for the design of the equipment. This can be done either by giving him responsibility for ongoing equipment modifications, or by giving him responsibility for the initial design of the equipment, as in a BOOM (Build, Own, Operate and Maintain) contract, which is gaining favour in many infrastructure projects.

Accordingly, there is a trend to contract the Original Equipment Manufacturer (OEM) as Maintenance Contractor for newly implemented projects, where equipment is not well known to the owner and it is still under warranty.

8.1.1.2 Evaluation of O&M Schemes

1) Operation Schemes

In this subsection we evaluate each type of contract approach by their own merit in consideration of possible funding schemes.

Operation by Concession

The first two types of contracts of the five mentioned in Table 8.1-1 correspond to the appropriate contract for an implementation funding under PPP scheme. They are applicable for either a wholly private funded project under BOT or in case of a funding scheme with a Public participation by means of Viability Gap Funding (VGF) or Hybrid scheme. A PPP scheme with Public contribution in the capital investment is the most probable funding scheme for funding the AER. In case of a fully private investment project, the Concessionaire owns the infrastructure and the Electro Mechanical (E&M) system, and in case of a Public participation on the capital investment (Hybrid), the Government would own the infrastructure and leases it to the Concessionaire, while the concessionaire owns the E&M system.

The main difference between these two schemes, the gross and net costs schemes, is who controls the revenue collection and the way of payment to the Private concessionaire. In case of the Net Cost Scheme the Concessionaire collects the revenue and pays an agreed fix amount or a percentage of the revenue to Government (the Implementing and Supervisory Agency, in our case maybe NLRC). Although the risk of low ridership rests on the Private party in this case, the concessionaire would usually request a kind of Minimum Revenue Guarantee (MRG). In case of Gross Cost Scheme the Government retains the fare revenue, by either collecting by itself or collected by Concessionaire and then transferred completely to Agency, and pays an agreed fix amount to Concessionaire. The risk in this case is entirely on the Government side.

There are some points that are worth mentioning for both cases, to wit:

- The Net Cost Scheme puts most of the risk on concessionaire, but to make the project commercially viable the Government is usually required to provide a MRG. However, the *floor line* should be carefully defined, as if it is too high will lead to lack of encouragement by the concessionaire to improve services or keep excellent maintenance, as a possible reduction in capacity will eventually not affect greatly its profit. On the other hand, it should be some kind of protection for the concessionaire if the planned railway network assumed during forecast analysis is not completed as scheduled by the Government.
- Under the Net Cost Scheme the Owner/Government has little hand-on control regarding operation and maintenance of the system (a.k.a. *Loss of Control*), and also difficult to gain experience for its own in-house technical staff (a.k.a. *Loss of Expertise*).
- In case of Gross Cost Scheme the Owner/Government bears all the demand risk; there is a fix amount to be paid to Concessionaire for O&M services, where such amount is bidden out prior to the selection of the Concessionaire. Therefore, there is no need of MRG.
- The Government (Implementing Agency) has more control on the operation and maintenance activities (supervisory control), but requires a sufficient level of technical capability to perform such supervisory control.

As we can clearly see both schemes have merits and demerits that are being weighted differently by different agencies around the world. The conditions, requirements and needs of each agency or government will rule the decision on the best appropriate contract scheme.

Each type of contract could be tailored to the needs of the Government and the project situation by incorporating specific clauses to address some issues mentioned above. For example, loss of control and expertise can be addressed by a tight requirement of performance supervision by the Owner to Concessionaire and approved training throughout the concession period to the in-house staff, respectively.

Third case of ODA + O&M leasing

The third type of contract of the six mentioned in **Table 8.1-1** correspond to a project implementation funded by Government's funds, either by ODA or other direct funding schemes. Albeit there is no contribution from Private sector on the project capital funding, except for Direct O&M by the Government, these schemes are also considered as PPP scheme as Private participation is still included in the operation and/or maintenance of the system, conveying some of the risks to the Private sector.

Once the infrastructure is built, the entire Operation and Maintenance is leased to a Concessionaire for a certain period of time based on public bidding. This scheme is usually implemented under Net Cost Scheme where the private sector assumed the market risk, but controls the revenue. The Concessionaire pays a fix amount to Government for the leasing of the facilities.

Direct Operation by Owner

The last three types of contracts of the six mentioned in **Table 8.1-1** correspond to a project implementation funded by Government's funds, either by ODA or other direct funding schemes. As mentioned above, albeit there is no contribution from Private sector on the project capital funding, except for Direct O&M by the Government, these schemes are also considered as PPP schemes as Private

participation is still included in the operation and/or maintenance of the system, conveying some of the risks to the Private sector.

All these cases the government, using own funds, contracts private contractors to build the infrastructure and E&M systems. The difference among them is the outsourcing of operations or maintenance. The case of maintenance outsourcing is evaluated in detail in subsequent subsections.

If Government has good financial condition this scheme could be applied, but the world trend is to include the participation of private sector to reduce the financial burden of the State, which could use those resources in other more urgent matters.

Therefore, the challenge is how to obtain private capital while adopting these schemes.

Furthermore, another challenge is how to obtain the know-how in the case of countries which have no experience with high-speed railway operation within the country, like Philippines. In order to resolve this, it is possible to construct infrastructure and E&M systems, and administer operations and maintenance while aiming for cooperation with private companies who have the expertise and specific know-how technology can be transferred to the local staff.

2) Maintenance Schemes

First of all, the advantages and shortcomings of outsourcing the railway maintenance works over in-house maintenance are enumerated below.

Benefits

Companies surveyed in the UK indicated that the main benefits were reported to be[1]:

Reduction the cost of obtaining the service	78%
Reduction in the headcount of the organization	65%
Increased flexibility of the business enterprise	61%

Very often not only the potential economical savings are identified as the main reason, but there are also other potential advantages that could defend a decision to outsource one or more activities:

- Outsourcing enables budget flexibility allowing operators to pay for only the services that are needed and when they are needed.
- Using a contractor to focus 100 percent on a particular area lets the Owner/Operator better manage existing assets, and focus in-house resources on core functions
- A trend toward outsourcing maintenance and adopting asset management applications is helping operators make the improvements which are crucial to keeping a railway system up and running, and keeping costs down.
- Warehousing and supply chain management will improve. Procurement of needed spare parts and equipment will be faster by employing technical experts doing the canvassing, evaluating, and testing up to acceptance of delivered spare parts.

[1] An Overview to Outsourcing – Trends and Different Options. SINTEF, Norway, Nov. 2003

- Less red tape or bureaucratic procedures. If maintenance is under the government, it always requires government ruling such as Commission on Audit, Government Procurement Act, etc. to carry out purchases of spare parts.
- Standby funds always available.
- It also reduces the need to hire and train specialized staff by the government operator, bringing in engineering expertise from the outside, and reduces capital expense, yielding better control of operating costs. Salary is attractive to acquire/hire qualified personnel (engineers. technicians, consultants, etc.).
- Unique technical expertise of the contractor, Improved quality of work and access to skilled personnel

Reduced risk

Nevertheless, one of the main reasons to resort to outsource the railway maintenance activities in case of a newly built railway system, in a country with no previous experience on mass transit railway systems, is the limited in-house resources, lack of equipment and expertise.

Secondly, as mentioned in previous subsection, the level of outsourcing, i.e., How much maintenance to be outsourced?, can vary, having advantages and disadvantages to each approach, and the most appropriate approach will depend on the client's particular situation.

Needless to say, the degree of involvement of the Owner/Operator in maintenance activities will depend greatly on the technical capability of its in-house work force.

In case of experienced and well established Operator around the world, when an outsourcing scheme is applied, they usually keep control what and when. However, in case of newly formed Operator or Owner/Agency, the approach would be to outsource all activities under an equipment performance type of contract (functional requirements or KPI).

Pitfalls and Concerns

In the previous sections we discussed potential benefits that could be the result of an outsourcing strategy. However, there is no guarantee that these benefits are achieved, and there could be also negative effects of the outsourcing:

Loss of control
Loss of expertise
Taxes
Contractor is not capable for doing the job

Loss of control

When work is outsourced to a contractor, the Owner/Operator transfers control over the activity that is outsourced to the contractor. To some extent, the Owner/Operator can assure against this by conducting audits to the contractor, but full control is almost impossible to obtain. The overall responsibility will be placed at the Owner/Operator, at least in the view of the public/customers.

Loss of expertise

A negative effect of outsourcing is often that the customer loses important knowledge, competence and expertise within the area that is being outsourced, or in case or a newly formed operator, they fail to gain suitable experience, remaining clueless of the maintenance procedures and skills.

"Loss" in here is applicable to existing experienced Owner/Operator "losing" expertise and control, but in case of a new Owner/Operator means losing possibility to acquire such expertise and control.

8.1.2 General Description of Maintenance Activities

8.1.2.1 Overall Maintenance Principles and Objectives

The overall objectives of the above philosophy are as follows:

- Safety of operation
- Reliability of the network and its component parts
- Availability of equipment, materials and facilities
- Provision of high quality of services

Maintenance activities should be carried out in the following manner:

- Planned periodic inspections of main system components in order to detect latent or apparent defects of materials and installations before the defective component affects the system and its performance.
- Recording of all system/component faults, their evaluation and their tendency to suffer from wear and tear (trend analysis) on a priority basis,
- Trouble-shooting in any situation (emergency included) for re-establishment of the functionality and performance of the transport system in accordance with safety standards.

1) Maintenance System Functions

Such maintenance activities require the following functions:

- Highly-qualified and well-trained maintenance staff
- Well-defined and efficient work method and workflows
- Well-organized (partially non-stop) workshop service
- Adequately-equipped workshops including tools, machines and installations
- Adequate logistic support
- Adequate information systems
- Flexible administrative and dynamic procurement systems
- Well co-ordinate interfaces between operation and maintenance
- Well organized spares and parts procurement.

2) Operation and Maintenance items

The items to be considered for Maintenance are:

A Electronic Services

- Automatic fare collection system
- Signaling/ Telecom system
- Electronic Laboratory
- SCADA system

B Infrastructure

- Building services
- OCS
- Power supply, Substation system
- Permanent way (trackworks)
- Civil structures (tunnels, viaducts, bridges)

C Rolling Stock

- Rolling stock
- Inspection facilities for rolling stock

Scope of Maintenance Services

The scope of maintenance services includes the following: Inspection, scheduled and unscheduled maintenance, and repairs for all AFC equipment; Special repairs for other than train sets; Management of spare parts and consumables for maintenance of AFC; Waste management and Labor for maintenance.

It is essential that a centralized point of control is set up to coordinate the maintenance and repair of all the above items. The final design of the depot should take into account everything that is necessary for efficient researching and carrying out of the various tasks involved in maintaining all the equipment and facilities in the AER System.

This maintenance plan should serve as a guidance and should not be considered as a detailed Maintenance Plan, which should be defined based, among other matters, on the actual equipment, rolling stock, OEMs, depot configuration, etc., which at the time of printing of this report, have not yet been defined. References to equipment and facilities of the system are assumed for a given common Express and Commuter systems. Some deviations in the final design of the system might be present, and they should be properly addressed on a final detailed Maintenance Plan.

The maintenance and repair of some equipment of AER Systems shall be contracted out to competent local contractors and OEM Authorized Dealer due to proprietary rights and difficulty in the procurement of vital parts.

8.1.2.2 Maintenance Services

Below is a general description of the maintenance activities that should be done for each subsystem. In this case is written for an outsourced maintenance contractor, but this is also valid for in-house maintenance schemes.

1) Quality and Service Objectives

The Maintenance Plan of the Maintenance Contractor for AER should be designed to meet very essential objectives that support the mission to create, nurture and sustain a high level of system of equipment and availability in order to provide high level of customer service and continuous improvement.

- Implementation of clear general Maintenance policies that would govern the management of the maintenance system.
- To receive and control all pertinent documents and records, drawings, parts list, operating and maintenance manuals turned over to NLRC by all concerned parties involved in the design, procurement, installation and construction of the System.
- Adoption and further improvement of the computerized asset Management System.
- Retention and recruitment of technical and administrative staff in the different areas of concern in the maintenance program will follow a HR Recruitment Plan in order to ensure the quality and competency of the personnel involved in the maintenance program.
- Duties and responsibilities of all personnel will be backed up with technical training to ascertain that know-how in the different railway fields is updated.
- System equipment will be ready and available to meet the performance requirements embedded in the General Maintenance Plan of the Maintenance Contractor.
- The Maintenance Contractor will provide all scheduled maintenance for all systems and equipment to obtain the highest level and quality of AER maintenance service.
- The Maintenance Contractor will provide all unscheduled maintenance for all systems and equipment to obtain the highest level and quality of AER maintenance service.
- The Maintenance Contractor will provide special repairs for all systems and equipment.
- Procurement of spare parts and materials will be implemented during the contract period.
- Planning, management and direction related to the general maintenance activities will be provided by the Maintenance Contractor.
- Regular assessment and evaluation on the maintenance activities, the Maintenance Contractor will recommend and suggest to the NLRC any modifications to all systems and equipment which may in the long run improve service, reduce costs or otherwise be beneficial.
- Reports on maintenance performance relative to performance requirements
- All service and maintenance requirements will be coordinated with NLRC to ensure that goals and objectives are appropriately met.

The Maintenance Contractor will provide for an efficient and effective ways of addressing the AER Maintenance work requirements by thoroughly and consistently following vital guidelines leading to a first-rate performance in the different essential areas in train service, reliability of the AFC System and the availability of station and depot ancillaries.

- **Trainset Availability** - The Maintenance Contractor will put into operation the number of train set available for service 2 train sets greater than the timetabled requirements or up to the maximum train-sets. Furthermore, train-sets for insertion into service must observe stringent compliance to good train requirement.
- **Train Service** - The Maintenance Contractor will be responsible in the maintenance of all systems related to the overall performance of AER Operation. This refers to the preparation and implementation of comprehensive, predictive and corrective maintenance programs for the rolling stock, power supply, overhead contact system, trackworks, signaling, telecom and walkway.
- **Automated Fare Collection Systems (AFCS) Availability** - the Maintenance Contractor will comply with the required performance of the AFCS that will be agreed upon with NLRC. This refers to equipment like Ticket Vending Machine, Automatic Gate, Analyzer Dispenser, .Station Computer System, central Computer System and Encoder System and their corresponding required performance.
- **Availability of Station Depot Ancillaries** - The Maintenance Contractor will be responsible in the preparation and implementation of comprehensive preventive, predictive and corrective maintenance programs for the following: escalators, elevators, telephones and radio communications, CCTV and Fire security Systems, air-conditioning systems, clock, chilled water system, water pumps, ventilation equipment, train wash, lighting, power plant, truing machine. Likewise, all service vehicles, railborne vehicles, trackwork equipment and workshop equipment. While these systems are non-vital, the Maintenance Contractor shall commit to achieve first-rate performance in these elements to provide service and comfort to the riding public as well as the maintenance service needs of the NLRC.

2) Automated Fare Collection System

The Automated Fare Collection System is considered a very important system of a railway line's operations because it directly relates with revenue and passenger service. Downed AFCS equipment could cause discomfort to the riding public and often become the subject of complaints.

Maintaining the AFCS equipment is a big task for the Electronics Services Department / Fare Collection Equipment Section. The Section would be responsible to maintain the operational condition of the AFCS comprising;

- ticket vending machine
- analyzer/dispenser
- automatic entry gates
- automatic exit gates
- automatic reversible gates
- station computer systems and
- encoder/sorter machine

Highly skilled personnel with expertise in electro-mechanical components will be tapped to handle the maintenance of the AFCS including manning of busy stations and terminals. These personnel shall be strategically distributed along the revenue line during the entire duration of the AER operations. They are to respond immediately to all the troubles in the AFCS equipment. It is also the section's objective to minimize such troubles that could affect the AFCS operations through proper maintenance.

3) Signaling System

Electronics Services Department/Signaling and Telecom Maintenance Section is responsible for the implementation of the maintenance plan covering all aspects of maintenance of the signaling equipment. The Signaling System of AER comprises a fix block with Automatic Train Protection (ATP).

Personnel under this section shall be assigned 24 hours a day in three shifts to oversee all maintenance requirements of the signaling equipment (wayside and on-board).

4) Telecommunication System

Electronics Services Department/Signaling and Telecom Maintenance Section is responsible for the implementation of the maintenance plan covering all aspects of maintenance of telecom equipment.

The Communication system includes Master Clock, Supervisory Control and Data Acquisition System (SCADA), Telephone, Radio, Closed Circuit Television (CCTV), Uninterrupted Power Supplies (UPS), train voice and data communication subsystem and other ancillary subsystem.

Personnel under this section shall be assigned 24 hours a day in three shifts to oversee all maintenance requirements of the telecom equipment.

5) Electronics Laboratory Services

The Laboratory Repair Section, as part of the Electronics Services Department, shall provide support and assistance by repairing the electronic parts and components of the rolling stock, AFCS, signaling and telecom equipment.

Component level repair and troubleshooting of rolling stock electronics.

Component level repair and troubleshooting of signaling and telecommunications electronics

Component level repair of AFCS equipment.

It is also the responsibility of the Laboratory Repair Section to maintain the operational condition of the Encoder/Sorter Machines of AFCS which will be very vital to the AER.

Highly trained personnel under this section shall be deployed on a regular shift for laboratory works during normal office work hours while they would have three shifts for the Encoder/Sorter Machines to monitor, maintain and respond to all the troubles in the Encoder/Sorter Machines 24 hours a day.

6) Buildings, Facilities and Equipment

From maintenance of building facilities and workshop equipment to design and shop fabrication, the Buildings, Facilities and Equipment Section under the Infrastructure Maintenance Department will be tasked to implement the maintenance plan for AER's building, facilities and equipment.

Personnel with experience in electro-mechanical and civil works shall compose the section and to be distributed in various shifts to answer all the maintenance requirements of the AER system. Motorpool and other equipments shall also be the responsibility of the section.

7) Overhead Catenary System

The Overhead Catenary System (OCS) as one of the vital parts of the AER system requires special attention. The Infrastructure Maintenance Department/Line and Catenary Section is tasked to handle the maintenance of the overhead catenary system.

The AER utilizes a 1500 V dc OCS. Tasked with this responsibility are personnel who have extensive experience in OCS construction, preventive and corrective maintenance and minor/major repair.

From inspection to major contact wire replacement, the catenary team can effectively respond to all the maintenance requirements of the OCS.

8) Power Supply System

The maintenance of AER electrical power supply system covers all the Rectifier Switching Stations (RSS) located strategically along the mainline route, including manning, and it shall be under the direct responsibility of the Power Supply Section, under Infrastructure Maintenance Department.

All activities, either preventive or corrective maintenance are covered in the maintenance plan designed for the power supply system with the objective of providing 100 percent reliability/uptime of the rectifier substations and continuous supply of power to stations and terminals, offices, AFCS equipment and rolling stocks of the AER system.

Being one of the vital components of the AER system, highly trained personnel composing the Substation Section would be in a 24 hour shifting duty to immediately implement maintenance works and all necessary actions required to normalize the system in times of power outages and momentary tripping in the substations.

Major/minor repair, corrective maintenance and transformer parts replacement are some of the unscheduled works that can be attended to/handled by substation technicians.

In addition to this, under the umbrella of the Power Substation Section is the Electrical Dispatching Unit, which is responsible for the conduct of switching at the rectifier substation during normal and abnormal situations in coordination with the Operation Control Center and personnel manning the affected substation. Most of the time, the electrical dispatcher also coordinates with a Manila electric power supplier to determine the power status from the source and if there are scheduled outages such that switching in the AER substation may be initialed in order not to disrupt operations.

The role of the Electrical Dispatching Unit is also very important in coordinating all works related to electrical systems such as catenary de-energization and isolation of zones inside the Depot area. Only personnel with actual experience in electrical dispatching are to be tapped to handle these tasks.

9) Track-works and Walkways

The Tracks Section, which will be under the Infrastructure Maintenance Department, shall be responsible in making the tracks along the AER route and inside the depot complex safe and available at all times through the implementation of an effective maintenance plan.

Daily patrol, track monitoring and data gathering are just some of the vital parts of the maintenance plan that was set up to ensure the safety passage of all trains on the entire AER track network. Maintenance activities for tracks and permanent ways are to be performed outside revenue service time, while track works inside the Depot will be done during daytime. Major/minor repair, corrective and unscheduled works shall be properly coordinated with the Control Center. Personnel under this section shall be

properly distributed into three shifts to effectively and economically deliver all the requirements stipulated in the maintenance plan.

10) Rolling Stock

The vital and principal equipment of AER railway system are the vehicles of heavy metro type. To ensure an effective and efficient rail maintenance capability for the system, the Rolling Stock Department is tasked to create, nurture and sustain the objective of the rolling stock maintenance program. This includes in general terms the two principal phases and the objectives of the maintenance program. The maintenance activities to be carried-out will ensure that all train set will be available for commercial service in accordance with schedule and under the safest operating conditions, reliability and passenger comfort.

To ensure Rolling Stock Maintenance Plan objective, the Rolling Stock Department shall be composing of top caliber maintenance people with extensive experience in rolling stock maintenance. Maintenance of heavy rail vehicles will be classified into 4 types: preventative maintenance, corrective maintenance, and special repairs and warranty or defects liability. The department will be divided into 2 sections,

Light Maintenance and Repair Section

The Light Maintenance and Repair Section will handle scheduled preventive and minor corrective maintenance activities of heavy rail vehicles.

Heavy Maintenance and Repair Section

Heavy Maintenance and Repair Section will be responsible for heavy rail vehicles scheduled annual maintenance overhaul, major corrective repair and major part replacement which will covered by warranty or defects liability.

Aside from the two Sections, a unit under Light Maintenance and Repair Section is the Yard, a Maintenance Liaison Office, tasked to ensure that any activity requiring maintenance involvement is addressed immediately and thus provide an extensive and effective yard management. The unit will be based in the Operations Control Center (OCC) to cover 24 hours 7 days a week and will perform and coordinate maintenance / technical activities and interface with the OCC. The unit extensive expertise will ensure smooth fleet transfer during the maintenance/repair or emergency situation. It will also be responsible for arranging and sorting of trains in the yard taking into account mileage grouping and schedule for deployment. All train movement inside the Depot will be maintaining with communication and close coordination with the OCC at all times.

11) Janitorial Services

The Maintenance Contractor should sub-contract its own Janitorial Services as part of the Contract for the Maintenance of AER System. This Sub-Contractor has to continue to provide janitorial services for 4 major asset items;

- Depot, its grounds, and buildings;
- all stations along the line;
- rolling stocks; and
- the rectifier substations

8.2 Project Implementation Schedule and Phasing

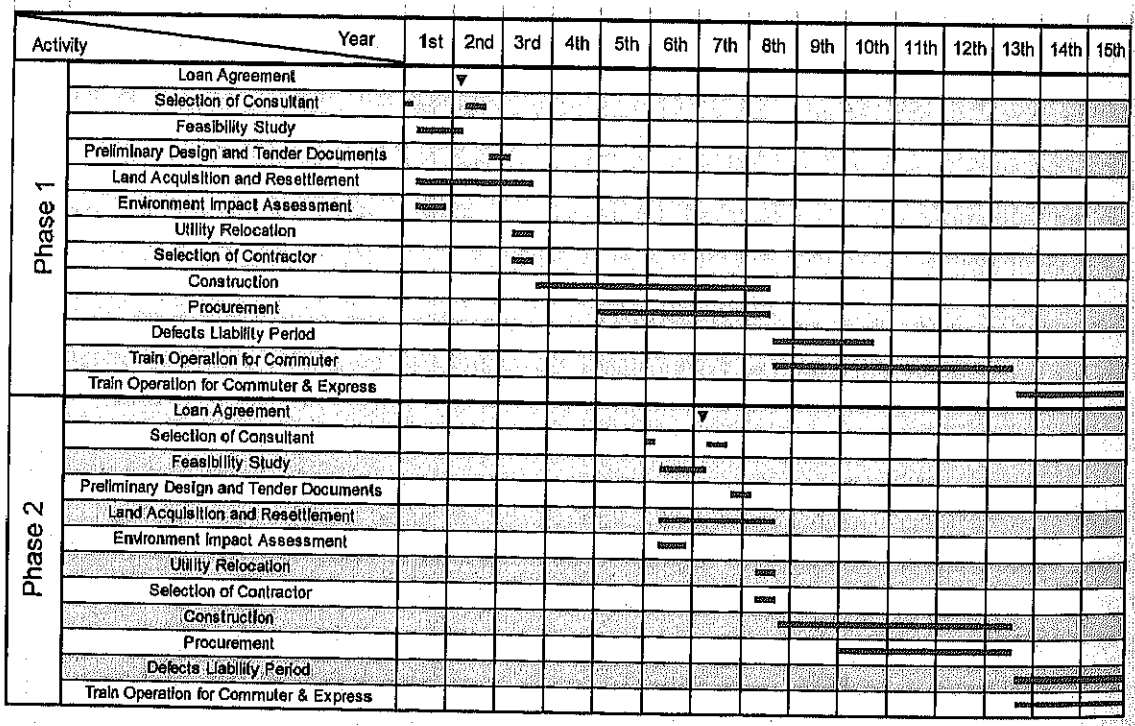
8.2.1 Project Implementation Schedule

After selection of the Route Alternative at the Pre-Feasibility Study Stage, it is necessary to carry out a Feasibility Study for the Selected Option of the Airport Express Railway in order to examine it deeply. An Environmental Impact Assessment will be completed during the feasibility study stage. After the preparation of the Feasibility Study, Preliminary Design and Tender Documents will be prepared for construction of AER. However, it is necessary to complete land acquisition and resettlement before commencement of construction. Environmental Monitoring will be carried out until the end of construction.

After Preliminary Design, Major Utility Relocation shall be completed before commencement of construction. In Case of Design build Contract Project、it seems to be more expensive for utility relocation cost if main utility relocation is included on the contract of contractor. Because the contractor will estimate utility relocation cost with any risk. Therefore, it is necessary to carry out main utility relocation before commencement of project. However, if utility relocation work will delay, the Contractor will make claim to the Employer due to delay in commencement of construction in the case of a Design Build Contract.

After Selection of the Contractor, construction will be started and run for 5 years including Train Test runs. It shall be required to complete within contract period without any delay. After completion of construction, Train Operation shall be started without any delay and then it should be required that Defects Liability Period will be started and run for 2 years in accordance with the Contract.

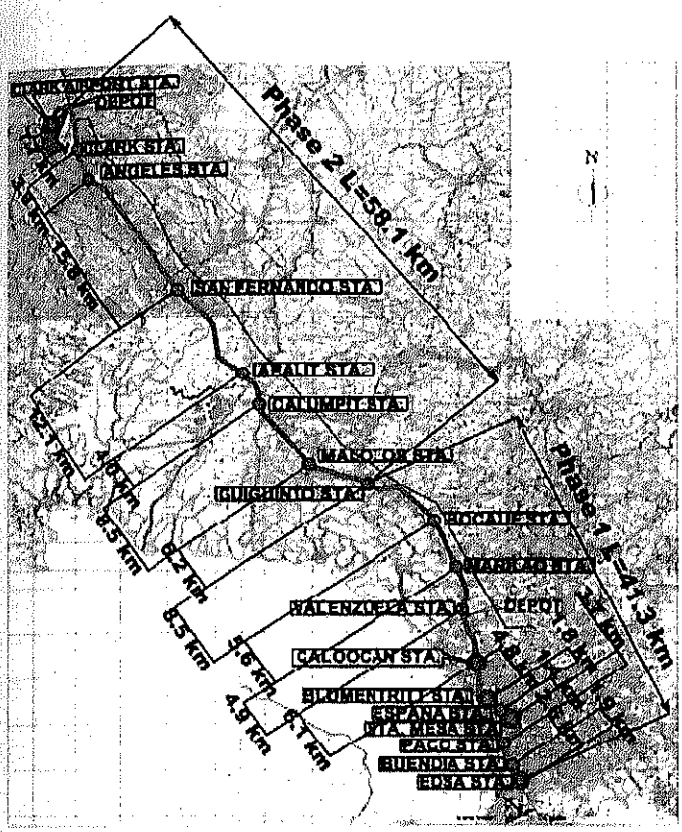
Table 8.2-1 Approximate Selected Option Project Implementation Schedule



Source: JICA Study Team

8.2.2 Phasing Schedule

8.2.2.1 Phasing with Phase 1 and Phase 2



Regarding the Airport Express Railway Alignment, it was selected using all PNR Route of approximately 100 km length by DOTC and JCC members during the JCC meeting. Project Cost is estimated to be approximately 600 Billion Yen. However it is too big to construct all infrastructures at one time. Therefore, it is proposed to divide it into 2 phases.

Phase 1 includes Elevated Structures for 45.2 km length. Underground structures for 3.2 km length and the Depot and Workshop. Phase 2 includes the Elevated Structures for 46 km length. Underground structures for 8.4 km length and the Depot.

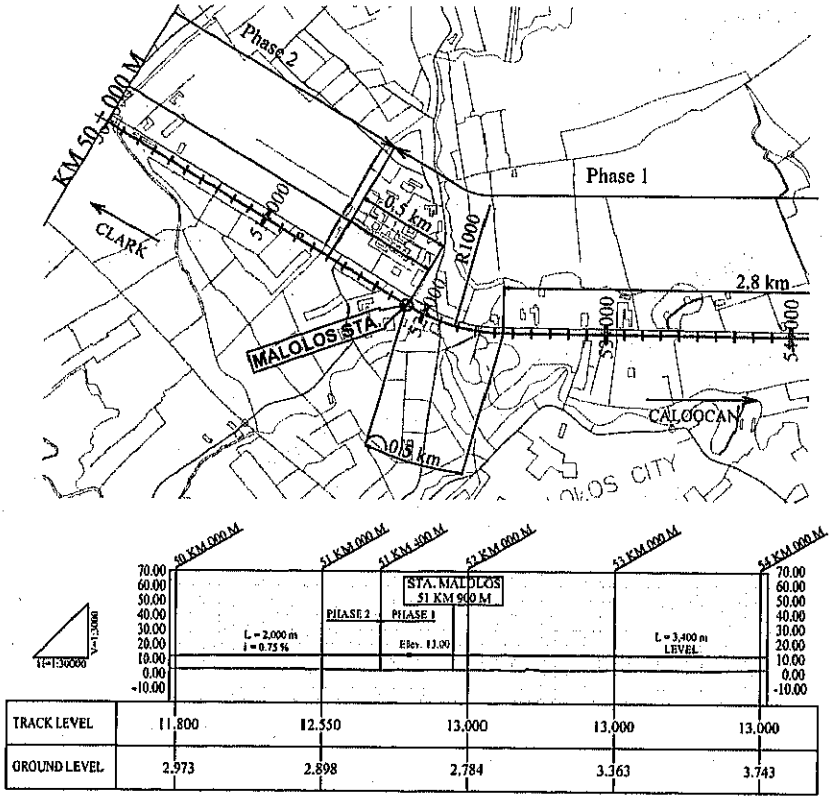
Source: JICA Study Team

Figure 8.2-1 Phasing with Phase 1 and Phase 2

8.2.2.2 Boundary between Phase 1 and Phase 2

If phasing will be divided into 2 Phases, it is being proposed to separate at the Malolos Area, because it is better to separate the 2 phases with total length and cost equally. Therefore, it is better that Phase 1 includes Malolos Station with the side track.

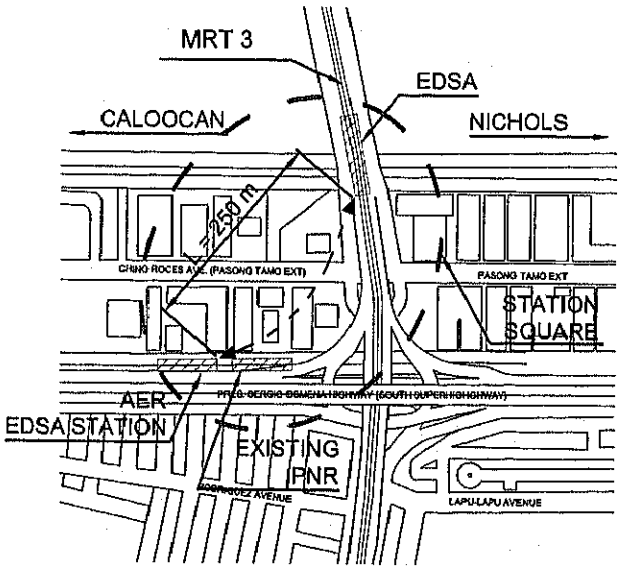
There is a depot near Valenzuela Station. There is no problem to separate at Malolos area when operation of Phase 1 will start. Malolos station is located between Guiguinto Station and Calumpit Station. There is a flooding area as low elevation same as sea level. It is necessary to implement counter measures for construction due to flooding.



Source: JICA Study Team

Figure 8.2-2 Boundary between Phase 1 and Phase 2

8.2.2.3 Terminal Station EDSA



Source: JICA Study Team

Regarding the terminal station of Phase 1, it was suggested by DOTC and JCC members to cut at EDSA Station because there is little demand forecast between EDSA Station and NAIA Station. There is MRT 3 EDSA Station near the AER EDSA Station. It shall be required to build an interchange station as convenience between MRT 3 and AER. Therefore, it is necessary to develop a station square between LRT Line 3 and AER.

However, it is necessary to examine the location of the terminal station in Phase 1 at next feasibility study stage because there is a big bus terminal planned near the FTI station. It is better to build the terminal station at the FTI station. However, the location of the terminal station would be considered in the feasibility study.

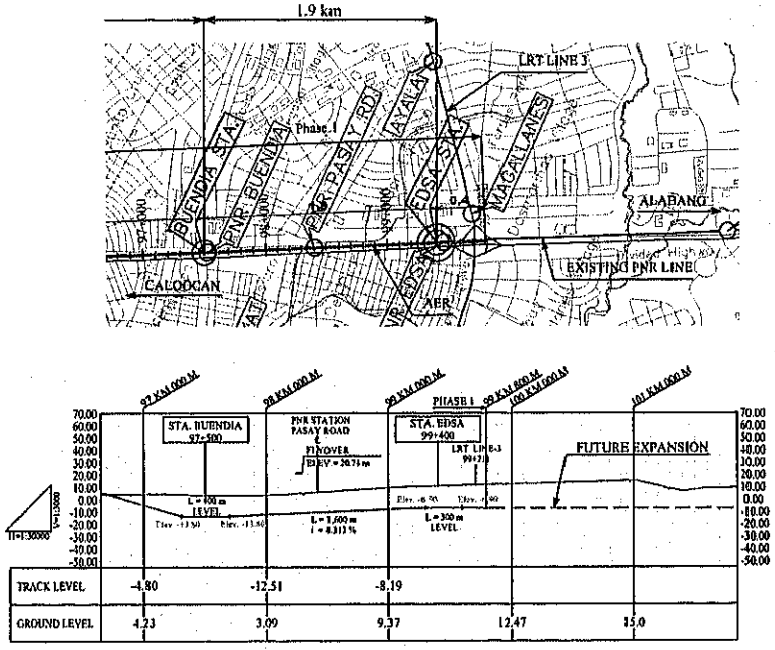
Figure 8.2-3 Terminal Station EDSA

8.2.2.4 Expansion of Phase 1 to the Southern Area

There are long distance trains between Tutuban Station and Mayon Station with 415km length under PNR. DOTC is planning to extend the AER to the southern area. Therefore, it is necessary to consider future expansion of the AER at the next Feasibility Study Stage

There is a crossing with more than 200m span with a Skyway between Nichols station and EDSA station over the PNR Route. It is very difficult to construct an Elevated Structure for expansion of AER to the southern area. Therefore, an Underground Structure will be examined for future expansion.

There are some alternatives for future PNR train operation after completion of AER. If the AER terminal station will be at EDSA, PNR train operation will be stopped before EDSA Station from Alabang Station.



Source: JICA Study Team

Figure 8.2-4 Expansion of Phase 1 to the Southern Area

8.3 Procurement Plan for Materials and Equipment

8.3.1 Rolling Stock

There is no supplier of rolling stock or rolling stock parts in the Philippines and all rolling stock used in existing railways have been imported. Rolling stock used in this project also must be imported.

8.3.2 Electrical and Mechanical Systems

The procurement plan for materials and equipment regarding the electrical and mechanical systems for the AER is shown in Table 8.3-1.

Table 8.3-1 Procurement Plan for Materials and Equipment - E&M System

System	Foreign currency	Local currency	Procurement Plan
1. Power Supply	85%	15%	The feeding system of a Japanese standard is adopted. A Japanese supplier implements the installation construction. Products of transformer and distribution facilities would be imported from Japan and the third country.
2. Catenary	75%	25%	Catenary of a Japanese standard which is able to respond to high-speed operation is introduced. Parts of the catenary would be imported from Japan and the third country.
3. Signaling	90%	10%	The CBTC system developed in Japan is adopted. Signal equipment would be imported by a Japanese signaling supplier and the installation construction would be implemented by them.
4. Telecommunications	90%	10%	The communications function used in Japan is introduced into the digital trunk radio of AER. Products of Telecommunications facilities would be imported from Japan and the third country.
5. Track Works	75%	25%	Slab tracks of Shinkansen specification and Solid bed tracks with removable sleepers of Japanese specification are adopted. End head hardened rails which have resistance to wear and turnouts which are able to respond to high-speed operation would be imported from Japan.
6. Depot Facilities	90%	10%	Depot equipment would be imported from Japan and the third country. The installation construction would be implemented by a Japanese supplier.
7. Automatic Fare Collection (AFC)	95%	5%	Specification of common ticketing system for integration of AFC of LRT 1, LRT 2, and MRT 3 is adopted.
8. Platform Screen Door (PSD)	95%	5%	Japanese-made PSD would be imported and the installation would be implemented by the Japanese supplier.
9. Early Earthquake Detection	95%	5%	Early earthquake detection system of Shinkansen specification is introduced.

Source: JICA Study Team

8.3.3 Civil

The Procurement Plan for Material and Equipment of Civil Work shall be assumed for Elevated Structures and Underground Structures of AER as shown in the following table. It is shown for each main material and equipment at the construction site with an Elevated Structure or Underground Structure. Each material and piece of equipment involves both Foreign and Local Currency. The cost estimation would be confirmed in detail at the next feasibility study stage.

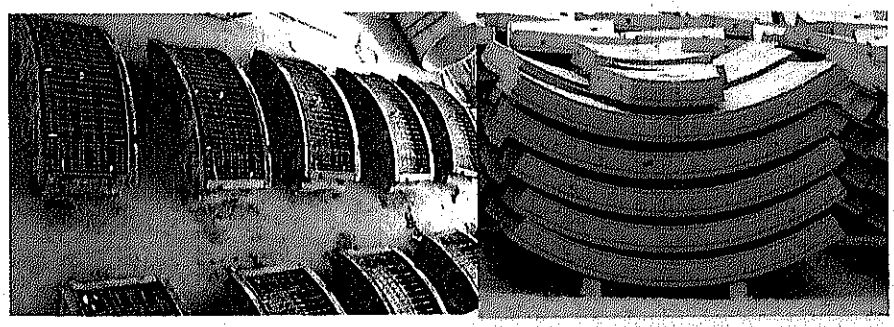
Table 8.3-2 Main Materials and Equipment

	Items	Currency		Construction Site			
				Elevated		Underground	
		Foreign	Local	Structure	Station	Structure	Station
Materials	Cement	△	◎	○	○	○	○
	Fine Aggregate	△	◎	○	○	○	○
	Coarse Aggregate	△	◎	○	○	○	○
	Rebar	△	◎	○	○	○	○
	Metal Materials	◎	△	○	○	○	○
	Shoe	◎	△	○	×	×	×
	Pre stressing Tendons	◎	△	○	×	×	×
	Water Proofing	◎	△	○	○	○	○
	Paint	◎	△	○	○	×	○
	Segment	◎	△	○	×	○	×
	Formwork	◎	◎	○	○	○	○
Equipment	Escalator	◎	△	×	○	×	○
	Elevator	◎	△	×	○	×	○
	Ventilation	◎	△	×	×	×	○
	Air Conditioner	◎	△	×	○	×	○
	Lighting	◎	◎	○	○	○	○

Legend ◎ - applicable △ - not applicable ○ - be used × - not to be used

Source: JICA Study Team

The main materials such as cement with different brands, fine and coarse aggregates and rebars are usually available in the Philippines. Other metal materials, shoe and pre-stressing tendons will be available from foreign sources. The precast segmental lining that is widely used for shielding and erector-arm tunneling, mainly in subway tunnels, is only available from foreign countries.



Source: JICA Study Team

Figure 8.3-1 Precast Segments for One-Pass Lining, Forms Stripped

Precast segmental linings are used in circular tunnels that are driven using a tunnel boring machine. They can be used in both soil and hard ground. Several curved precast elements or segments are assembled inside the tail of the tunnel boring machine to form a complete circle.

The tunnel drives will be supported with a bolted and gasketed pre-cast concrete segmental lining. This watertight lining system will be designed to withstand construction, ground, hydrostatic, and seismic loads. Manufacture of the pre-cast concrete will be undertaken by specialist personnel with previous experience in this operation. Established quality control/quality assurance will be implemented in order to produce a high-quality product.

Regarding temporary equipment, it is shown for each main piece of temporary equipment at the construction sites with Elevated Structures or Underground Structures. The main pieces of Temporary Equipment involve both Foreign and Local Currency.

Table 8.3-3 Main Temporary Equipment

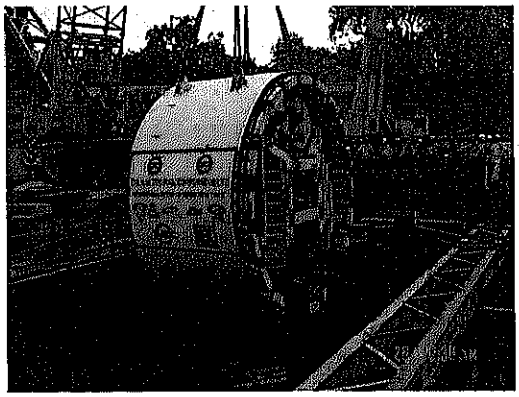
Items	Currency		Construction Site			
			Elevated		Underground	
	Foreign	Local	Structure	Station	Structure	Station
Crawler Crane	◎	△	○	○	×	○
Earth Auger	◎	◎	○	○	×	×
Scaffolding	◎	△	×	○	×	○
Concrete Pump	◎	△	○	○	○	○
Generator	◎	△	○	○	○	○
Backhoe	◎	△	○	○	×	○
Dump truck	◎	△	○	○	×	○
Ramer	◎	△	○	○	×	○
Vibrator Roller	◎	△	○	○	×	○
Mobile Lift	◎	△	○	○	×	×
Erection Gantry	◎	△	○	×	×	×
Sheet pile	◎	△	○	×	×	○
Trench Timbering	◎	△	×	×	×	○
Tunnel Boring Machine	◎	△	×	×	○	×
Covering plate	◎	△	○	×	×	○
Temporary Elevator	◎	△	×	○	×	○
Temporary Lift	◎	△	×	○	×	○

Legend ◎ - applicable △ - not applicable ○ - be used × - not to be used

Source: JICA Study Team

The main pieces of temporary equipment like the crawler crane are currently only available from foreign countries while other different types of earth augers used for soil drilling are currently available nationwide. Other equipment such as scaffolding, concrete pumps, generators, backhoes, dump trucks and rammers are all available from foreign countries. But, in some construction businesses here in the Philippines, most of the major project contractors bought and imported that equipment from foreign countries and made it available in the Philippines for rental purposes.

Regardless of which type of TBM is selected, these machines will be capable of exerting a balancing pressure against the tunnel face, which will be used to control excavation rates, groundwater inflows and maintain stability of the excavated face. Tunnel Boring Machines (TBMs) are designed to provide maximum flexibility regardless of the ground conditions that the project may encounter. This is a special tool for the construction of an underground (subway). This technology has been applied in various countries such as Japan and in Europe. TBMs have the advantages of limiting the disturbance to the surrounding ground and producing a smooth tunnel wall. TBMs, however, are expensive to construct and can be difficult to transport. TBM will be imported from foreign countries in this project.



Source: JICA Study Team

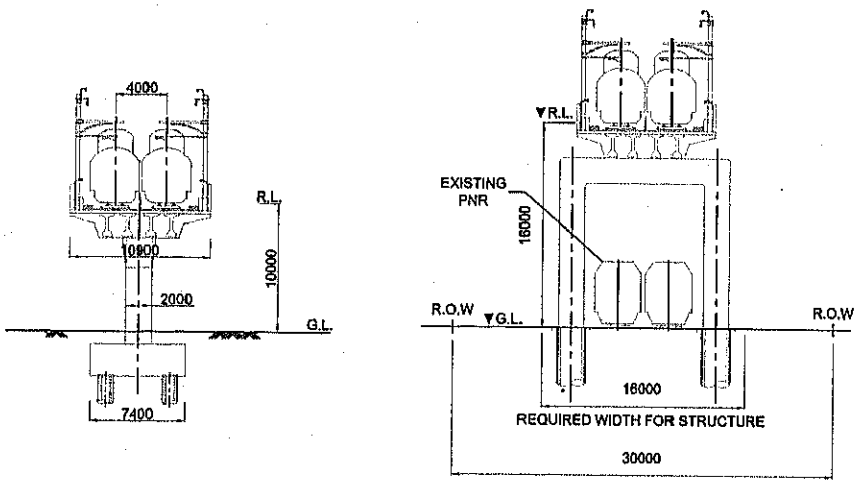
Figure 8.3-2 Tunnel Boring Machine

8.4 Construction Plan

8.4.1 Structure Type

1) Elevated Track Way Structure

The PC Beam Girder with a single pier has been recommended as the Elevated Structure for all options generally. In case of PNR Operation to be remained, a Portal Pier Type should be adopted over railway track under operation. However, construction of the Portal Pier will involve more cost and time than the Single Pier Type due to consideration of the PNR operation.



Single Pier with PC Beam Girder Portal Pier with PC Beam Girder

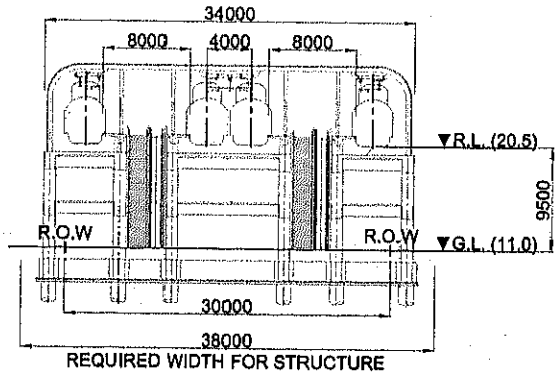
Source: JICA Study Team

Figure 8.4-1 Elevated Track Way Structures

2) Elevated Station Structure

An Elevated Station Structure shall be recommended for 2 Platforms & 2 Tracks and 2 Platforms & 4 Tracks including Rigid Frame and Portal Pier for the Selected Option.

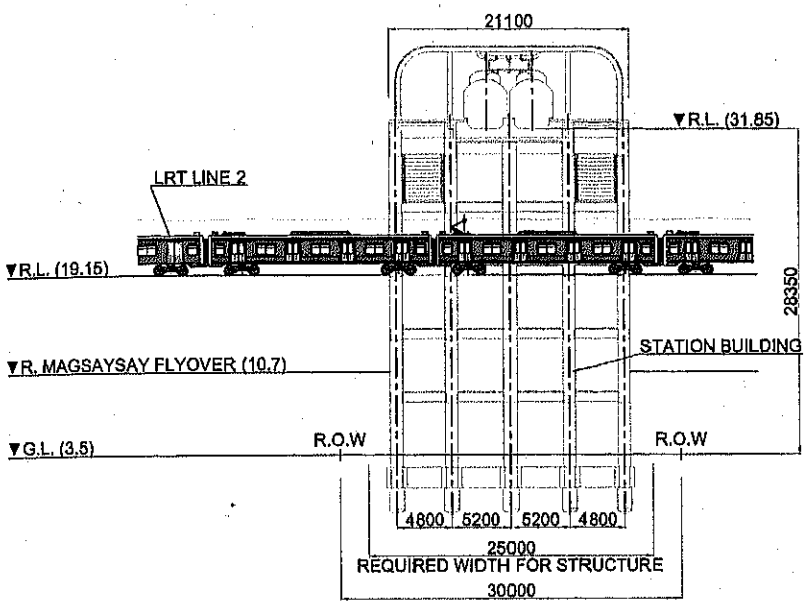
An Elevated Structure with 2 Platforms & 4 Tracks of Rigid Frame Structure shall be recommended between Caloocan and Clark with a siding track for passing of the Express Train. However, it is necessary to get additional land for the additional siding track.



Source: JICA Study Team

Figure 8.4-2 Elevated Station with 2 Platforms & 4 Tracks of Rigid Frame Structure

An Elevated Station with 2 Platforms & 2 tracks of Rigid Frame Structure shall be recommended for Sta. Mesa and Blumentritt Station with much higher track alignment because LRT 1 and 2 with Elevated Structure and Road Flyover is near both stations.

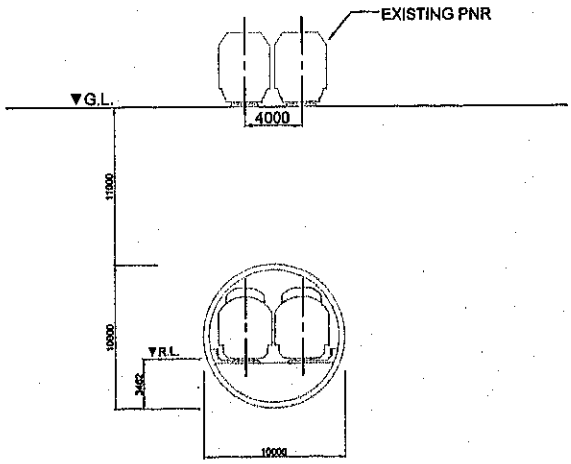


Source: JICA Study Team

Figure 8.4-3 Structure Elevated Station with 2 Platforms & 2 Tracks of Rigid Frame Structure near LRT line 2

3) Underground Track Way Structure

Double Tracking Tunnel by Tunnel Boring Machine Method shall be recommended within narrow ROW. It is necessary to maintain a distance of more than 1 tunnel diameter between the tunnel and the ground surface.



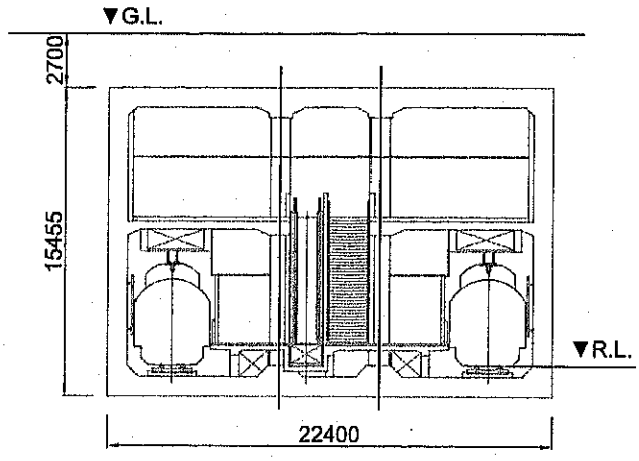
Source: JICA Study Team

Figure 8.4-4 Double Tracking Tunnel

4) Underground Station Structure

An Underground Station Structure shall be recommended for 1 Platform & 2 Tracks, and 2 Platforms & 4 Tracks for the Selected Option.

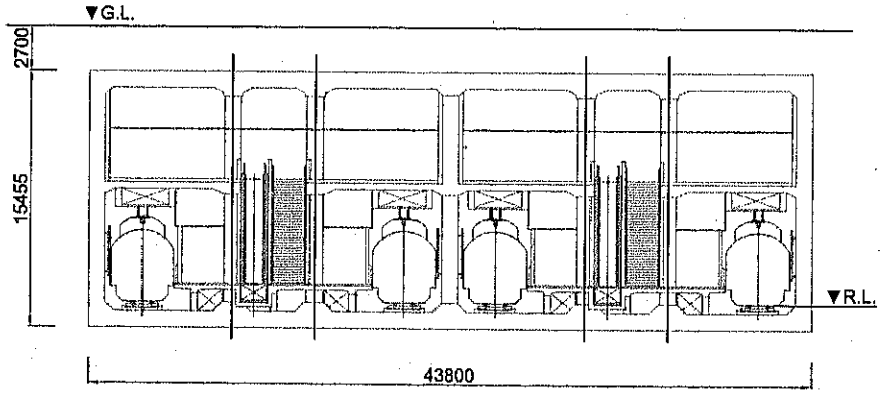
It consists of a concourse on the level of basement 1 and a platform on the level of basement 2. It is necessary to have an entrance on both sides of the station from outside of the station.



Source: JICA Study Team

Figure 8.4-5 Underground Station with 1 Platform & 2 Tracks

An Underground Station with 2 Platforms & 4 Tracks shall be recommended as the Terminal Station at Clark Airport. It consists of a concourse on the level of basement 1 and a Platform on the Level of basement 2.



Source: JICA Study Team

Figure 8.4-6 Underground Station with 2 Platforms & 4 Tracks

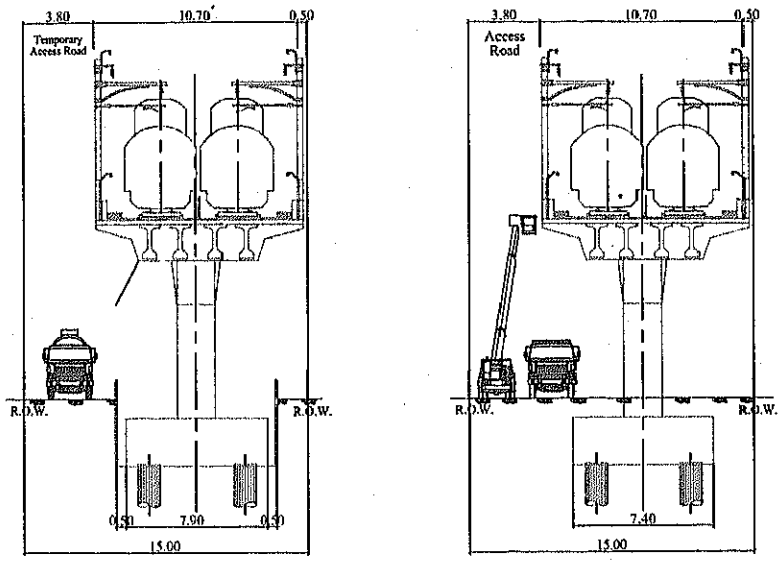
8.4.2 Construction Workability

1) ROW width for Elevated Structures

There is narrow right of way around San Fernando Station. This could pose a problem with access to the site during construction. There are many houses beside the right of way in Angeles City. This too could pose a problem with access to site during construction.

There are narrow ROW between Angeles and Caloocan on the PNR Route in some areas. During construction of the Elevated Structures, it is necessary to have more than 15m width for the Access Road because many trucks, truck mixers and cars use the access road to the site. After construction, it is required to keep more than 15m width for the access road because it is essential to use the access road for maintenance or emergency evacuation.

It shall be recommended to get additional land to provide width of more than 15m in the currently narrow ROW areas.



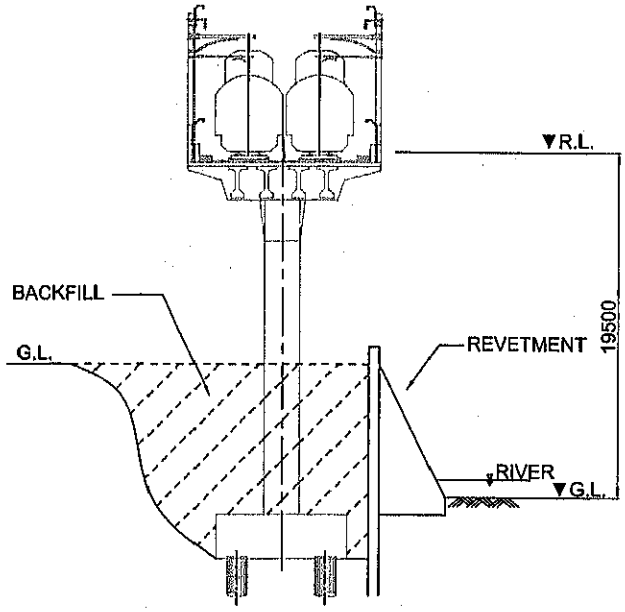
Source: JICA Study Team

Figure 8.4-7 ROW width for Elevated Structures

2) Erosion Area

There is an erosion area with 1.9 km length due to river flow between Angeles and San Fernando on the PNR Route. It is necessary to install revetments for the substructure as protection before construction of the Elevated Structure.

There is no access near this area. It is necessary to install a temporary access road in order to proceed smoothly with the construction.

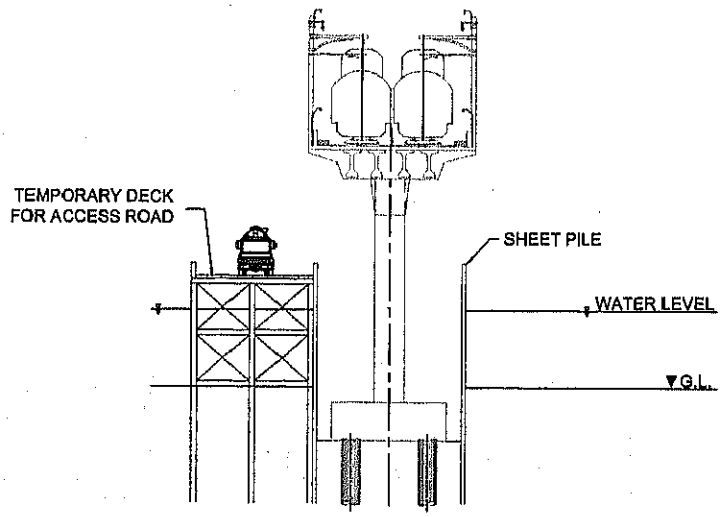


Source: JICA Study Team

Figure 8.4-8 Revetment for Substructure

3) Swampy Area

There swampy areas between Malolos and San Fernando on the PNR Route. It is necessary to install a temporary steel stage for transportation of machinery or materials during construction due to the swampy areas. It is necessary to install sheet piles to avoid an intrusion of ground water during construction of the substructure. Construction Cost could increase due to flooding, especially in the rainy season.



Source: JICA Study Team

Figure 8.4-9 Temporary Stage and Sheet Pile

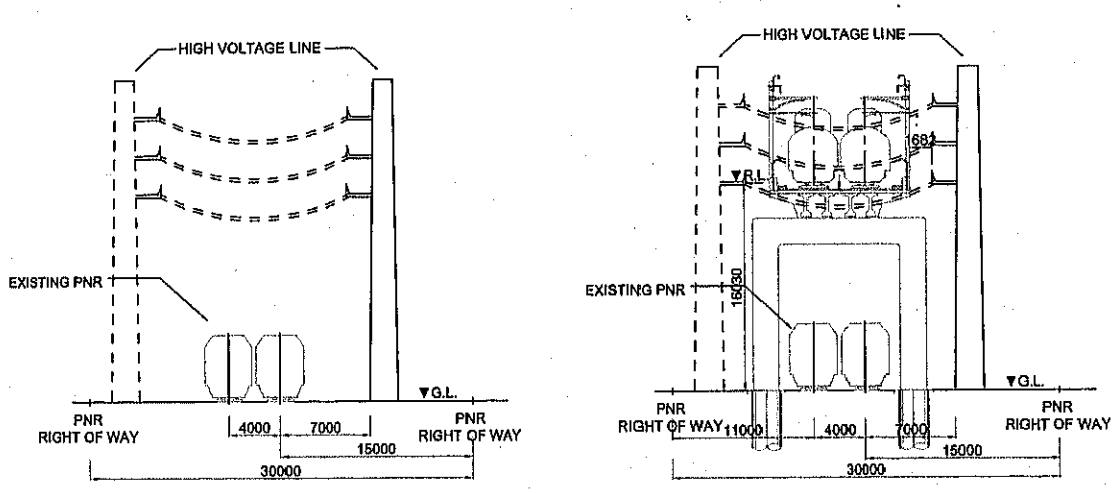
4) Flooding Area

It is necessary to implement countermeasures regarding station level planning against heavy rain because of the low ground level between Malolos and Caloocan. At the same time it is necessary to consider construction method regarding countermeasure.

There is no problem with an access road to the site along the main road in this area. However, even if it does not have enough width of Right of Way along the main road, it is necessary to consider an access to the site because there were problem with an access to the site at China Loan.

5) High Voltage Line along PNR Route

There are many high voltage poles on both sides along the PNR Route between Pandacan Station and Nichols Station. It is necessary to relocate those high voltage poles before construction in order to enough coordinate with power company and related agency.



Source: JICA Study Team

Figure 8.4-10 High Voltage Line along PNR Route

6) Station Structure Type on PNR Route Inside of Manila

The approximate station size is considered for the Selected Option on the PNR of inside Manila as shown in the following Table. However, it will be necessary to calculate platform size based on the demand forecast in the next Feasibility Study Stage. All stations will need to get additional land for the station area because the table below does not include entrance space. All stations need to install entrances.

Table 8.4-1 Approximate Station Size on PNR Route Inside of Manila

Existing PNR Station	AER Station						
	Name	Type of Station	Type of Platform	Platform Width	Station Width except entrance	Station Height	Station Length In case of Train Formation for 10 cars
Caloocan	Caloocan	Elevated	2 Platforms & 4 Tracks	8m+8m	36m~40m	Under consideration	210m~220m
Blumentritt	Blumentritt	Elevated	2 Platforms & 2 Tracks	8m+8m	22m~26m	Under consideration	210m~220m
Laon-Laan	-	-	-	-	-	-	-
España	España	Elevated	2 Platforms & 2 Tracks	8m+8m	22m~26m	Under consideration	210m~220m
Sta. Mesa	Sta. Mesa	Elevated	2 Platforms & 2 Tracks	8m+8m	22m~26m	Under consideration	210m~220m
Pandacan	Future Station (Pandacan)	-	-	-	-	-	-
Paco	Paco	Elevated	2 Platforms & 2 Tracks	8m+8m	22m~26m	Under consideration	210m~220m
San Andres	San Andres	-	-	-	-	-	-
Vito-Cruz	Future Station (Vito-Cruz)	-	-	-	-	-	-
Buendia	Buendia	Underground	1 Platform & 2 Tracks	12m	22m~24m	-	240m~260m

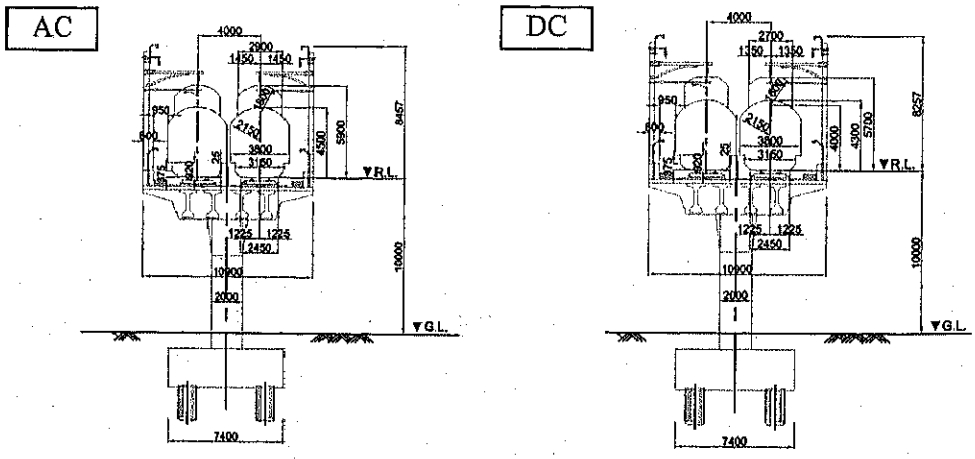
Source: JICA Study Team

8.4.3 Construction Gauge

It shall be prohibited to install railway facility or any structure within construction gauge except train in accordance with railway regulation in Japan. At the same time it shall be prohibited to place any material on out of construction gauge to be able to collapsed to construction gauge. There are some construction gauges for elevated structure, elevated station, underground structure and underground station. It shall be compared with Alternating Current and Direct Current for each structure type as the following.

1) Elevated Structure

Construction gauge for AC is bigger than 200mm height and 200mm width as part of catenary against DC in case of bridge. Therefore it seems to be not so different cost between AC and DC because it is increased only for cost of Pole of Overhead Catenary for AC.

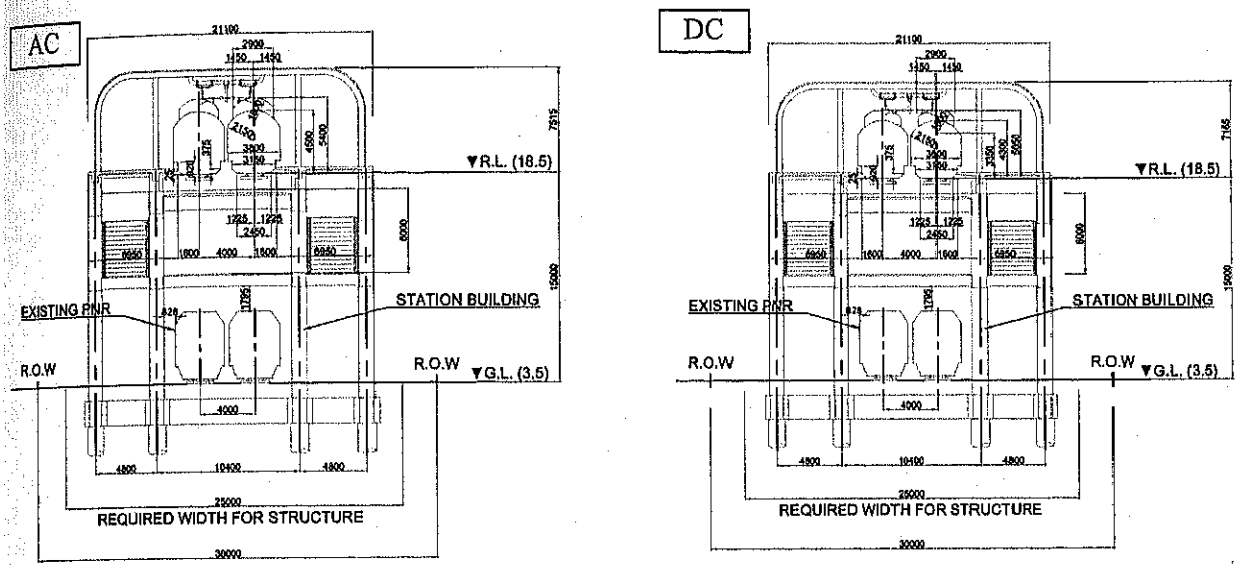


Source: JICA Study Team

Figure 8.4-11 Comparison with AC and DC of Elevated Structure

2) Elevated Station

Construction gauge for AC is bigger than 350mm height and 200mm width as part of catenary against DC in case of station. Therefore, it seems to be a little bit more expensive due to higher roof structure for AC.

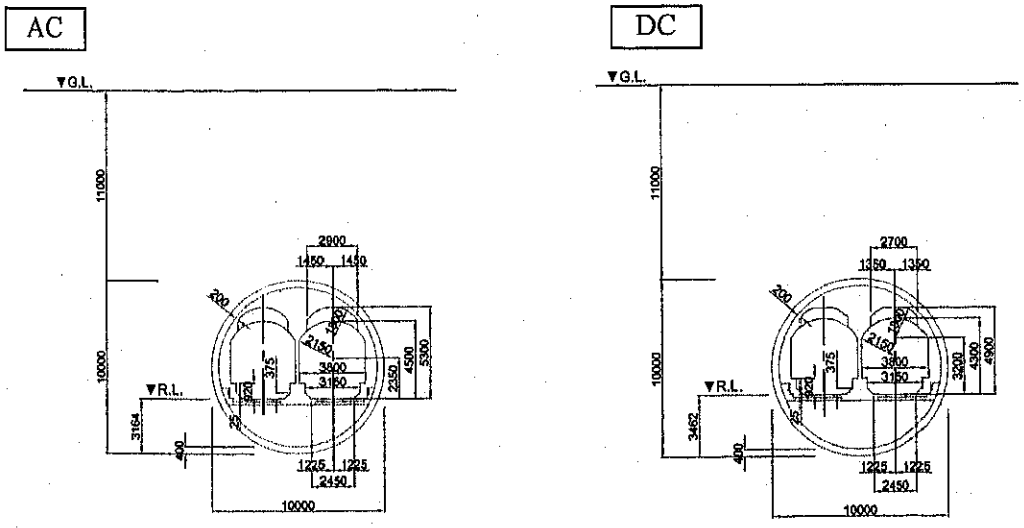


Source: JICA Study Team

Figure 8.4-12 Comparison with AC and DC of Elevated Station

3) Underground Structure

Construction gauge for AC is bigger than 400mm height and 200mm width as part of catenary against DC in case of Tunnel Structure.



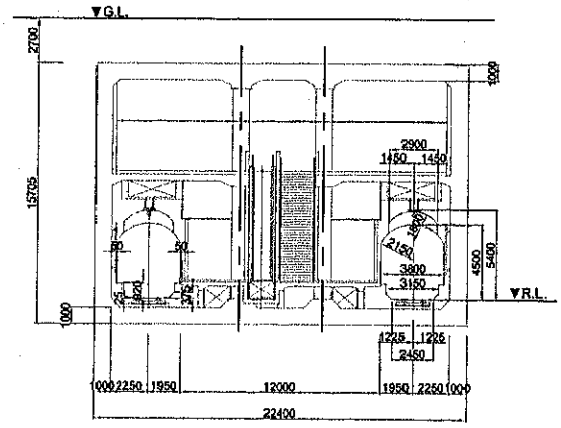
Source: JICA Study Team

Figure 8.4-13 Comparison with AC and DC of Underground Structure

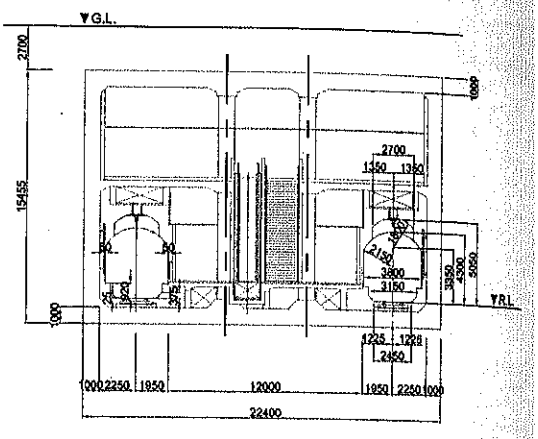
4) Underground Station

Construction gauge for AC is more bigger than 350mm height and 200mm width as part of catenary against DC in case of Underground Station.

AC



DC



Source: JICA Study Team

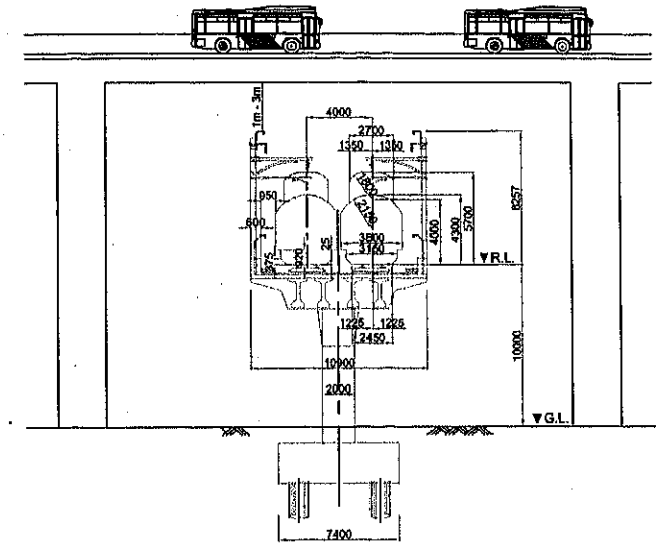
Figure 8.4-14 Comparison with AC and DC of Underground Station

8.4.4 Clearance

Clearance is required to secure minimum distance with approaching situation due to shaking and bending of cable by alteration of natural condition for reference in Japan.

1) Clearance between Railway and Road Flyover

There is a minimum clearance between railway structure and road flyover. It is required to keep more than 1m to 3m case by case in accordance with railway regulations in Japan. It would be considered for clearance between Railway and existing structure in detail at next feasibility study stage.

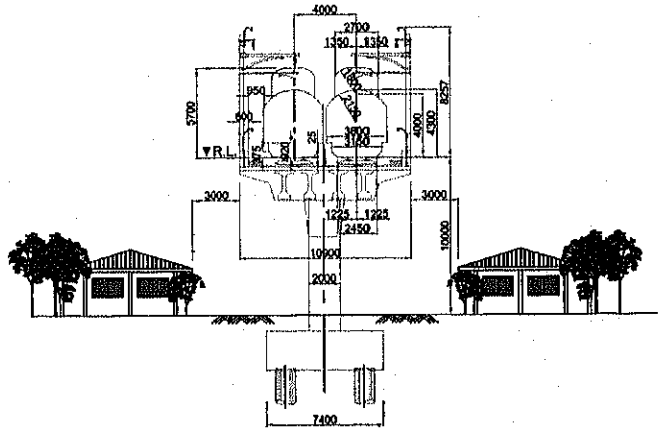


Source: JICA Study Team

Figure 8.4-15 Clearance between Railway and Road Flyover

2) Clearance between Railway and Residential

According to the National Building Code of the Philippine (PD 1076) of Department of Public Works and Highways (DPWH), it is mentioned minimum setbacks between road and residential building and structure. Regarding to the railway infrastructure, it seems to be required to have clearance between railway structure and residential structure. Therefore, it would be better to be examined this matter at next basic design stage.



Source: JICA Study Team

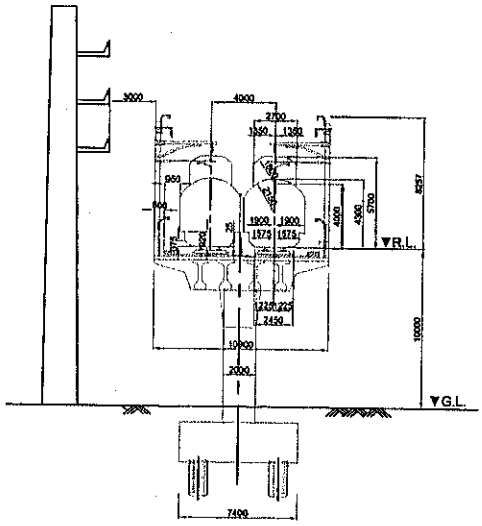
Figure 8.4-16 Clearance between Railway structure and Residential building

3) Clearance between Railway and High Voltage Line

There is minimum clearance between railway catenary system and high voltage line in accordance with railway regulation in Japan.

There are high voltage line along PNR Route between Sta. Mesa Station and EDSA Station. Therefore it is necessary to consider clearance between Railway and High Voltage Line to coordinate with Power Company.

If it would be in accordance with Japan regulation、it might be required to keep 3m clearance as horizontal distance and 2m to 4.6m clearance as vertical distance based on each high voltage.



Source: JICA Study Team

Figure 8.4-17 Clearance between Railway and High Voltage Line

8.5 Project Implementation Cost

8.5.1 Summary of Project Cost

Based on the preconditions, project costs have been estimated including basic cost, land acquisition cost, tax, engineering cost and physical contingency. Basic cost has been estimated for Civil Work, E&M System Work and Rolling Stock as construction and procurement direct cost.

Table 8.5-1 Project Cost

(Mil USD)

Items		Phase 1 (Year 2020)	Phase 2 (Year 2025)	Total
Basic Cost	Civil	1,703	1,624	3,327
	E & M System	818	894	1,712
	Rolling Stock	184	455	639
	Total	2,705	2,973	5,678
Land Acquisition Cost & Compensation		14	46	60
Utility Relocation Cost		54	60	114
Tax	Import Duty	194	175	369
	VAT	325	357	682
Engineering Cost		322	350	672
Physical Contingency		266	289	555
Total Cost		3,880	4,250	8,130

Source: JICA Study Team

Prices in January 2013 were used for the cost estimate of construction and procurement as the following precondition. Price contingency is ignored to make analysis in real-terms. Land acquisition Cost and Compensation is prepared with the assumptions based on material from NLRC.

- Exchange Rate
  1 USD = 85.81 JPY
  1 USD = 41.06 PhP
  1 PhP = 2.09 JPY
- Inflation Rate
  Foreign 2.1% p.a.
  Local 2.6% p.a.
- Import Duty
  7.0 ~ 12.0% for Machinery and Equipment
- VAT
  12% for Basic Cost
- Engineering Cost
  10% for Basic Cost and Tax
- Physical Contingency
  7.5% for Basic Cost, Tax, Engineering Cost except Land Cost
- Utility Relocation Cost
  2% for Basic Cost

8.5.2 Rolling Stock

The implementation cost of the rolling stock, which is estimated on the basis of Japanese standard specifications for a DC 1500V power supply system, is shown in Table 8.5-1. In the case of an AC Power supply system or some equipment corresponding to other special requirements, additional cost would be incurred. The additional cost between the AC system and DC system would be borne at any time rolling stock is introduced or replaced.

Table 8.5-2 Project Implementation Cost

System	Foreign currency	Local currency	Implementation Cost (Mil-USD)				
			Phase 1 year 2020		Phase 2 year 2025		Total (Mil-USD)
			Train sets	Cost	Train sets	Cost	
Commuter	100%	0%	8	184	+12	+276	460
Express	100%	0%	0	0	+8	+179	179
Total	100%	0%	8	184	+20	+455	639

Source: JICA Study Team

8.5.3 Electrical and Mechanical Systems

The project implementation costs regarding the electrical and mechanical systems for AER are shown in Table 8.5-3.

Table 8.5-3 Project Implementation Cost

System	Foreign currency	Local currency	Implementation Cost (Mil-USD)		
			Phase 1 year 2020	Phase 2 year 2025	Total
1. Power Supply	85%	15%	190.4	259.7	450.1
2. Catenary	75%	25%	105.1	114.8	219.8
3. Signaling	90%	10%	114.2	104.9	219.1
4. Telecommunications	90%	10%	96.0	76.6	172.6
5. Track Works	75%	25%	162.0	185.4	347.5
6. Depot Facilities	90%	10%	110.6	44.2	154.8
7. Automatic Fare Collection (AFC)	95%	5%	39.8	19.9	59.7
8. Platform Screen Door (PSD)	95%	5%	0.0	66.4	66.4
9. Early Earthquake Detection	95%	5%	0.0	22.1	22.1
Total Amount			818.0	894.0	1,712.0

Source: JICA Study Team

8.5.4 Civil

1) Project Cost

Project Cost consists of Quantity and Unit Price as a rough cost estimation at the pre-feasibility stage for selection of route alignment. Regarding the quantities of the project, plan and profile drawings must be prepared for the area between Clark and EDSA based on the selected option alignment with vertical and horizontal track alignment before calculation of quantities can be undertaken. And then quantities of the materials for the structures will be calculated in order to select the structure type based on the selected option track alignment.

The underground structure unit price is 85 Mil USD per km and the elevated structure unit price is 55 Mil USD per km including E&M system and rolling stock.

Table 8.5-4 Elevated Structure Cost

Items		PC Beam Girder						Box Girder	Total
		Single Pier				Portal Pier		Long Span Bridge	
		Standard	High	Swampy	Erosion	Standard	High		
Phase 1	Quantity (km)	33.8	0	0	0	0	9.5	1.9	45.2
	Cost (Mil USD)	608.4	0	0.0	0.0	0.0	348.8	68.4	1,025.6
Phase 2	Quantity (km)	30.7	1.9	10.0	1.9	0	0	1.5	46.0
	Cost (Mil USD)	552.6	51.3	216.0	44.5	0.0	0.0	54.0	918.4
Total	Quantity (km)	64.5	1.9	10.0	1.9	0	9.5	3.4	91.2
	Cost (Mil USD)	1,161.0	51.3	216.0	44.5	0.0	348.8	122.4	1,944

Source: JICA Study Team

Table 8.5-5 Elevated Station Cost

Items		2 Platforms & 2 Tracks				2 Platforms & 4 Tracks				Total
		Rigid Frame		Portal Pier		Rigid Frame		Portal Pier		
		Standard	High	Standard	High	Standard	High	Standard	High	
Phase 1	Quantity (stations)	5	3	0	0	1	1	0	0	10
	Cost (Mil USD)	125.0	90.0	0.0	0.0	30.0	36.0	0.0	0.0	281.0
Phase 2	Quantity (stations)	3	1	0.0	0.0	1	0	0	0	5
	Cost (Mil USD)	75.0	30.0	0.0	0.0	30.0	0.0	0.0	0.0	135.0
Total	Quantity (stations)	8	4	0	0	2	1	0	0	15
	Cost (Mil USD)	200.0	120.0	0.0	0.0	60.0	36.0	0.0	0.0	416.0

Source: JICA Study Team

Table 8.5-6 Underground Structure Cost

Items		Horizontal Twin Tunnel	Double Tracking Tunnel	Cut and Cover Tunnel	Total
Phase 1	Quantity (km)	0.0	0.0	3.2	3.2
	Cost (Mil USD)	0.0	0.0	160.0	160.0
Phase 2	Quantity (km)	0.0	5.4	3.0	8.4
	Cost (Mil USD)	0.0	207.9	150.0	357.9
Total	Quantity (km)	0.0	5.4	3.4	11.6
	Cost (Mil USD)	0.0	207.9	170.0	517.9

Source: JICA Study Team

Table 8.5-7 Underground Station Cost

Items		2 Platforms & 4 Tracks	Total
Phase 1	Quantity (stations)	2.0	2.0
	Cost (Mil USD)	125.0	125.0
Phase 2	Quantity (stations)	1.0	1.0
	Cost (Mil USD)	62.5	62.5
Total	Quantity (stations)	3.0	3.0
	Cost (Mil USD)	187.5	187.5

Source: JICA Study Team

Table 8.5-8 Depot and Workshop

Items		Depot & Workshop	Total
Phase 1	Quantity (ha)	12.0	12.0
	Cost (Mil USD)	111.0	111.0
Phase 2	Quantity (ha)	18.0	18.0
	Cost (Mil USD)	150.0	150.0
Total	Quantity (ha)	30.0	30.0
	Cost (Mil USD)	261.0	261.0

Source: JICA Study Team

2) Unit Prices

Regarding the unit prices of the project, they are prepared for each structure type including elevated structures and underground structures based on similar railway projects for the Airport Railway projects and MRT projects in the world including Bangkok Airport line, Delhi Airport line and Jakarta MRT project.

Table 8.5-9 Elevated Structure and Station Unit Price

Items			Unit Price (Mil USD)			
			Standard	High	Swampy	Brosion
Structure	PC Beam Girder	Single Pier	18.0	27.0	22.0	23.0
		Portal Pier	31.0	37.0	-	-
	Box Girder	Long Span Bridge	-	36.0	-	-
Station	Rigid Frame	2 Platforms & 2 Tracks	25.0	30.0	-	-
		2 Platforms & 4 Tracks	30.0	36.0	-	-

Source: JICA Study Team

Table 8.5-10 Underground Structure and Station Unit Price

Items		Unit Price (Mil USD)
Tunnel	Horizontal Twin Tunnel	35.0
	Double Tracking Tunnel	39.0
	Cut and Cover	50.0
Station 2 Platforms & 4 Tracks		62.5

Source: JICA Study Team

Table 8.5-11 Example for Urban Railway Project Price

	ITEMS	Bangkok Airport	Bangkok MRT Blue Line	Bangkok MRT Purple Line	Sofia Metro Extension Project	Delhi Metro Line Phase 1	LRT Line 1 North Extension Project
Civil Works	Elevated Structure (Mil USD/km)	9.0	-	13.4	-	-	-
	Elevated Station (Mil USD/station)	11.7	-	34.1	-	-	6.06 (excluding M&E)
	Tunnel (Mil USD/km)	-	96.6	-	25.3	22.7	-
	Underground Station (Mil USD/station)	-	Mil USD /km (all underground)	-	25.9	34.3	-
	Track (Mil USD/km)	2.29	6.28	5.2	2.29	-	2.64
	Depot (Mil USD)	19.7	226	168	-	-	-
E&M Works (Mil USD/km)		13.3	29.2	19.5	6.68 (excluding rolling stock)	-	8.1 (excluding rolling stock)
Civil and E&M Works (Mil USD/km)		30.9	143.4	71.7	56.5	53.9	24.7

Source: JICA Study Team

CHAPTER 9

RAILWAY OPERATION AND MAINTENANCE MANAGEMENT SYSTEMS

CHAPTER 9 RAILWAY OPERATION AND MAINTENANCE MANAGEMENT SYSTEMS

This Chapter would aim to propose an organization scheme for the implementation of AER and later its corresponding Operation and Maintenance (O&M).

However, the scope of this chapter would also include the initial discussion of a broader organization that would be in charge of the overall railway system of the Philippines.

9.1 Implementation

9.1.1 Legal Aspect

9.1.1.1 Proposal for the Establishment of Philippines Railway Authority (PRA)[1]

The creation of an autonomous Philippines Railway Authority (PRA) as a governing body for setting transport policy, regulatory parameters, and for implementing all Railway Programs, is recommended. The key objective of the creation of a new entity is to provide for:

- Changes in the regulation of public transport operations as Government operator as well as in joint venture with the private sector,
- Enforcement of regulations,
- Land acquisition power,
- Joint development of stations with the private sector,
- Franchising at stations, supplementary licensing for mass transit railways
- Regulatory powers
- Overall railway planning
- Leverage local and central government funds, external assistance as well as private funds, support private investment and to create a conducive environment to utilize the efficiencies, innovativeness, flexibility and speed of the private sector to provide better infrastructure and service at an optimal cost.
- Setting up a transparent, consistent, efficient administrative mechanism to create a level playing field for all participants and protect the interests of all stakeholders
- To prepare a projects list to be implemented under General Appropriations Act (GAA), ODA, or to be offered for PPP and take them forward with assistance of the highly qualified staff through a transparent selection process.
- Putting in place an effective and efficient institutional mechanism for speedy clearance of the projects.

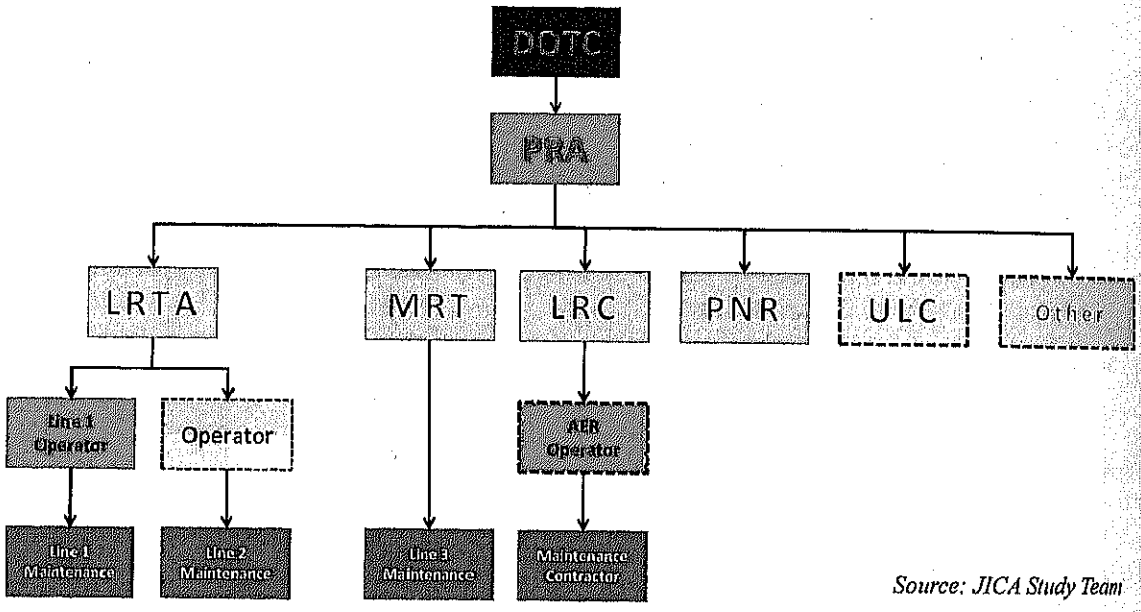
[1] *Proposed name. Final name to be decided by Philippine authorities.*

9.1.1.2 The Implementing and Operating Agency (Owner/Concessionaire)

The Airport Express Railway (AER) would be the first suburban mass transit project in Metro Manila, and even in the entire Philippines. The operating organization will be newly established under the umbrella of the future PRA, also under the existing Government agencies and supported by GOP and DOTC so that no other Ministry or local Government will directly execute operation.

This section describes the organization plan of Luzon Railway Corporation (LRC)[2] in terms of its positioning, role and responsibility as Railway Supervisory/Operator & Implementing Agency, and indicates those responsibilities and tasks that could be given in concession according to the type of PPP scheme, if any, adopted during the implementation of the AER.

Figure 9.1-1 shows the concept of the new PRA and its relationships with existing and future entities. The LRC legal set up and by-laws should be similar or mirrored to the legal framework of NLRC and LRTA.



Source: JICA Study Team

Figure 9.1-1 Concept of new Hierarchy for Railways in Philippines

9.1.1.3 Creation of PMO

During the implementation of the project under the LRC, a Project Management Office (PMO) is created as the organization to be in charge of the actual implementation of the project and liaison with the Consultant, Contractor, and other concerned stakeholders. As the formal establishment of the LRC and PRA would take time, an interim PMO, within the authority of DOTC, shall be set up.

This PMO should take responsibility for the initial duties until the formal establishment of the PMO within LRC. The staff of the former should be absorbed by the latter. The staff of this PMO will be critical for the success of the project and the LRC.

The main scope of works of the PMO is summarized below:

- Reviews the Consultants design methods, standards and criteria used in the preparation of the

[2] *Proposed name*

design;

- Assures that the Contractor's work complies with the plans and specifications of the contract by conducting regular site inspections.
- Monitors work accomplishment of the contractors.
- Analyzes and interprets financial statements/reports;
- Responsible for all matters relating to taxes and transactions related to the Bureau of Internal Revenue;
- Responsible for the safekeeping of all project records and correspondence.
- Coordinates with LRC Accounting Division and Commission on Audit regarding financial transactions of the PMO.
- Coordinates with the ODA Bank's Representatives regarding the PMO's disbursements financed from ODA loans, if any.
- Prepares all financial reports other than the PMO's financial statements as may be required by LRC, NEDA and fiscal authorities/other agencies.
- Monitors and assists in the verifications of disbursements that are financed under the ODA loans (Foreign Currency).

9.1.2 Scope of Work

The following Table 9.1-1 shows the list of tasks LRC is responsible for in the service operation and maintenance. This is the key to which tasks an individual party can access, review, handle and ultimately how a task is routed and approved.

Among the tasks and duties mentioned in Table 9.1-1 above, the Operations (III) and Maintenance (IV) are the tasks that could be given in concession to a private party in case such party has entered into a PPP with LRC and requires return on investment.

Table 9.1-1 LRC Tasks and Duties

No.	Task Category	Description of the Task Category
I.	Management	To formulate policies, prescribe and promulgate the rules and regulations for the attainment of the objectives of the PRA Implements, enforces, and applies the policies, plans, standards, guidelines, procedures, decisions, rules and regulations issues, legal affairs, and public relations.
II.	Administration	The administration-related departments and section shall advise and assist the Management in the formulation and implementation of rules and regulations necessary to carry out the objectives and policies of the authority concerning administrative, finance, accounting, budget, human resources, etc.
III.	Operation	To ensure the safe, reliable and efficient operating of the railway and satisfactory service to the passengers on a day-to-day basis.
IV.	Maintenance	To perform the daily and the long term planning and execution of scheduled and unscheduled, preventive and corrective maintenance actions to ensure overall systems are ready for required operation at all times.
V.	Engineering & Construction	Advise and assist the Management in the formulation and implementation of rules and regulations necessary to carry out the objectives and policies of the PRA/LRC concerning engineering. Monitor and be counterpart of Consultants and supervise Contractors.

Source: JICA Study Team

9.1.3 Organization Structure and Staffing of LRC

9.1.3.1 Organization Structure

Consistency of responsibility and autonomy will facilitate integration of the O&M perspective into system design, which will reduce lifecycle costs and achieve long-term sustainability. Such a system would also make it possible to identify future LRC leaders (technical managers required for the O&M phase) during the E/S and construction phases. Early identification of future leaders from the PMO organization will lead to early capability-building activities in the organization, as they develop competency and acquire a holistic understanding of the integrated systems.

The LRC organization shall start with a core team (i.e. PMO), and it will gradually evolve into its full form before start of the O&M phase. With the LRC in charge of all phases, the engineers, supervisors, technicians, and operators (required for O&M phase) can be trained during the construction phase by the system contractors and Original Equipment Manufacturers (OEMs) to equip them with necessary knowledge and skills to handle supervisory tasks for the O&M activities effectively. The technical training should be done by visiting successful cases overseas and by inviting contractors and OEMs to Manila. There should also be independent training on management and operational skill development, such as financial and business planning, maintenance auditing and service operations and general problem-solving.

All successful overseas metro systems, such as the Tokyo and Delhi Metros, share four key principles in their organizational design:

- The rail business unit is designed as a function-based organization. This is necessary to achieve the required level of competency in each railway system function, which needs to have specialized functional areas.
- The non-rail business unit (non-core) is designed differently from the rail business unit (core). This is important because the culture, skills, recruitment process, and business unit basis differ for the two businesses. Railway businesses require rigid adherence to technical standards to ensure safety and achieve specific operating standards, while non-rail businesses need creativity and flexibility to enhance non-fare box revenue.
- All decision-making authority is delegated to the board. Complete empowerment of the LRC Board of Directors can achieve transparent corporate governance, faster decision-making, and rapid project implementation.
- An internal independent safety monitoring unit is important for controlling the system's safety and security by monitoring daily O&M activities. Since a railway system involves running trains through narrow passages with a high density passenger load, it is critical to ensure safe and secure operations.

9.1.3.2 Staffing

Steps in Establishing the Operations and Maintenance System

1) Planning/Basic Design Stage

The hardware plan for the railway is essentially something that must be decided based on what sort of system will implement a certain kind of operation. Therefore a person who mainly carries out that operation is required when planning a railway.

Generally, in an urban railway, a local government authority will, based on urban transport policies, independently carry out facility planning based on an operations structure and a standard of provided services.

In order to implement this, the LRC must be established prior to the planning stage of Manila Metro, or the main planning body is set up and a system is put into place for possible discussion by the members who can fulfill the primary role of the LRC in the future.

Therefore, if it is firmly suggested to develop the AER, the LRC or the LRC preparatory organization (collectively referred to as the "PMO") must be established as soon as possible.

2) Construction Bidding/Construction Management Stage

After the completion of basic planning and procurement of the necessary capital for construction, implementation of bidding and ordering and construction management will be conducted by the LRC. At this stage, it is also necessary to procure the needed personnel in order to implement outsourcing of construction management as well as bidding.

Therefore, it is necessary to start the recruitment of personnel six months before the completion of basic planning, and when the basic planning is completed, it will only be necessary to secure the suitable personnel to transfer for bidding works.

3) System Expansion towards the Start of Business

Prior to the start of business operations, it will be necessary to train the personnel, particularly for the drivers which require at least 30 drivers for the start of operation. If continuity is taken into consideration, 200 drivers should be employed after that time. Due to the large numbers of required drivers, it is proposed that employment of a number of instructors shall be carried out at the stage when on-site

training is possible in order to avoid last minute training.

Personnel who will be trained overseas require compliance for the acceptance by the concerned parties abroad, the objective is to obtain driving licensees that will undergo real-vehicle training.

To this end, 10 Filipino personnel will be required beforehand. After one year of training in Japan with proper education to become instructors, the personnel will conduct training to the driver including test drives at the start of operations for part or a section of the completed area. In case the period of training in the Philippines will take one year and the test drive will take six months to complete, training in Japan for the driving instructors will have to take place two and half years before the start of operations. Since it will take a long time to train everyone, recruitment will have to start more than three years before the start of operations.

It will not be a problem if the training period in other areas is short compared to drivers, but train control center personnel require six months training before the start of test driving. There are 10 personnel, so a Japanese person will conduct training at the actual site. In order to be able to start training, recruitment will need to be done one year before starting operations. Furthermore, two people are required to undergo an instructional course in Japan to become leaders.

The training period for station employees should take half a year from the start of test driving. However, the number of personnel is very large, and because it will not be cost-effective to have Japanese instructors, 20 local personnel (1 in 10 out of more than 200 people) will be recruited as instructors and will undergo an instructional course in Japan for one month.

Therefore, employment to secure the necessary number of station personnel will be carried out half a year before the start of operations. However, two persons per area should be employed before that to undergo training in Japan.

Furthermore, regarding maintenance, it is necessary to decide what to do regarding the division of outsourcing and self-production as well as the assignment of outsourcing. In order to address this at the start of test driving, it is necessary to proceed with preparations for each.

9.2 Operation

9.2.1 Proposed Operation & Maintenance Scheme

Given a proper setting of LRC as mentioned above, LRC should engage in the task of implementing the AER. As the operation scheme will be decided in a later stage, this subsection introduces our proposed maintenance scheme, which is a general description of the most appropriate scheme for this project, and it is independent from the mode of implementation that would be finally selected, whether a fully ODA, PPP with two-tiered, Net or Gross Cost, etc., thus, suitable to any funding scheme.

The Study Team, taking in consideration all available information, site conditions, potential technical and financial capabilities of future LRC, is suggesting the following maintenance scheme for the AER: The Concessionaire/Operator shall outsource the maintenance activities, preferably to a contractor closely linked or associated to the main OEM (Rolling Stock). The Concessionaire/Operator shall outsource to a Maintenance Contractor all the maintenance activities, including, among others, light & heavy maintenance, troubleshooting, and procurement of capital and consumable spare parts.

The reasons to choose this scheme are that up to date, the implementing and supervisory agency LRC has not yet being established. Then, it is not baseless to say that the required technical level of knowledge and capability to have a direct control of the O&M activities would not be achieved by its in-house staff by the time of the opening for revenue of the first line.

Due also to the complexity and difficulty of the maintenance of the E&M systems, and the condition of having a Warranty period in effect right after the opening for commercial revenue, it is highly

recommendable to subcontract (outsource) all maintenance activities to a well experienced and capable contractor, preferably to the rolling stock OEM, as it is one of the critical and more complex railway subsystems that should be properly maintained.

9.2.2 Scope of Work

We first suggest the outline of the responsibilities to be addressed by and between the LRC, which is represented as the owner/Authority (A), the Concessionaire/Operator (O), if any, otherwise its responsibilities lay on LRC, and the Maintenance Contractor (C). A basic matrix of tasks and duties for the three stakeholders is shown in **Table 9.2-1**.

The basic concept of sharing of duties is that the Owner approves, the Operators monitor, and the Contactor implements the Maintenance Plan, which is prepared based on policies and guidelines for maintenance, and the OEM maintenance guidelines. They all should be bound by two contracts: a Concession Agreement between LRC and the Operator (in case of Net Cost Scheme) or Service Agreement (in case of Gross Cost Scheme), and a Maintenance Contract between the Operator and Contractor for a period between 3 to 5 years.

Table 9.2-1 Tasks & Duties Matrix for Maintenance

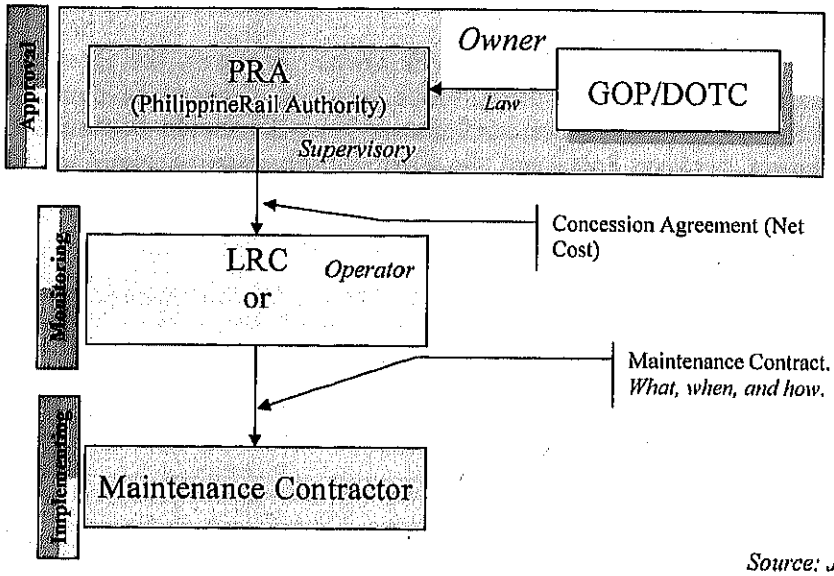
	Task	Responsibility		
	Maintenance	**A**	**O**	**C**
1	• Formulate policies and guidelines in the maintenance of rolling stock, E&M subsystems, and civil works		☑	
2	• Approve policies and guidelines in the maintenance of rolling stock, E&M subsystems, and civil works	☑		
3	• Implement policies and guidelines in the maintenance of rolling stock, E&M subsystems, and civil works			☑
4	• Inspect repair maintenance activities of the maintenance contractor		☑	
5	• Implement of all maintenance activities related to rolling stock, E&M subsystems, and civil works			☑
6	• Approval of special repairs and corrective maintenance activities		☑	
7	• Approval of large rehabilitation programs of capital equipment	☑		
8	• Monitor Maintenance progress implementation of all maintenance activities by using CMMS		☑	
9	• Monitors the performance of the contractor and oversee the proper implementation of Quality Assurance/Quality Control of all maintenance/repair works.		☑	
10	• Audit/approve status reports of the maintenance of the tools and equipment;		☑	
11	• Supervise and monitor the Contractor to plan and procure local and foreign spare parts, material, tools and equipment;		☑	
12	• Plan and procure local and foreign spare parts, material, tools and equipment;			☑
13	• Supervise the control of inventories and the issuance of spare parts;		☑	
14	• Responsible for the control of inventories and the issuance of spare parts;			☑
15	• Prepare annual materials/spare parts budget (local and imported) for the operation and maintenance of the system;			☑
16	• Assist in managing the procurement process;		☑	

Source: JICA Study Team

The monitoring and supervision of the maintenance activities should be done using a Computerized Maintenance Management System (CMMS). Currently, the software MAXIMO© is one of the most widely used as CMMS.

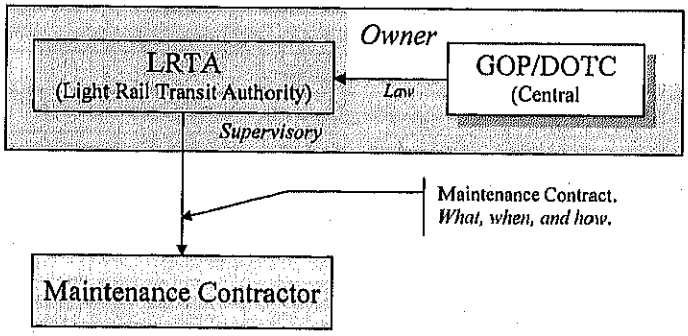
Capital equipment (rolling stock, subsystems, etc.) replacement due to end of life cycle or new acquisition due to capacity expansion is the responsibility of the Owner or Concessionaire depending of the type of contract, if any.

Accordingly, all parties (the Owner, Operator, and Maintenance Contractor) should adopt the concept of fully integrated teams. The recommended functional organization structure is shown in the following figure. As an example, in the case of LRTA, the relationship between parties is shown in **Figure 9.2-2.**



Source: JICA Study Team

Figure 9.2-1 Functional Organization Structure for O&M Scheme



Source: JICA Study Team

Figure 9.2-2 Functional Organization Structure in case of LRTA

The following measures should be taken in consideration to avoid the issues seen in other railway systems;

- It is important that the Owner/Operator be able to have some hands-on control over the maintenance process in order to maintain the growth of the capacity building of the in-house workforce at all levels, especially the technician level.

- Although in the beginning all works should be assigned to the Maintenance Contractor, eventually, LRC would desire to have more control and expertise throughout Capacity Building programs over the years in order to reach a level where the ***what*** and ***when*** are controlled by the Owner/Operator.
- Approved training programs should be carried out periodically to the benefit of the LRC's in-house technical staff in all related activities of the O&M of the system.

Eventually, LRC should be able to take more responsibilities, control, and risks in time for the implementation of new railway lines (extension) that will increase the network in Luzon, and also in time when the Concession Agreement for the AER expires, and LRC would have to take control.

9.2.3 Organization Structure and Staffing

9.2.3.1 Human Resources for O&M Activities

(1) Human Resources (HR) Goals

The Maintenance Contractor has put a human resource management plan in place to address the entire term contract for Maintenance Works of AER staffing and skills needs. This plan encompasses six goals.

Goal 1: Proactive and Visionary Leadership

To support the Maintenance Objectives to renew, create, nurture, revitalize and sustain an effective, safe and cost efficient rail maintenance capability for the AER System and to provide all Maintenance Contractor staff with a clear sense of the Maintenance Contractor's vision, mission, goals and objectives.

Goal 2: Performance Focused Workforce

To ensure that all Maintenance Contractor employees have a clear understanding of how their job is linked to high level of system and equipment reliability and availability and Maintenance Contractor goals and objectives, and to recognize and reward excellence in employee performance.

Goal 3: Flexible and Motivating Work Environment

To promote and support employee wellness, and a healthy balance between work and personal life, and to provide all new employees with an opportunity to attend a Maintenance Contractor orientation session, training and seminars.

Goal 4: Learning and Innovative Organization

To establish a Maintenance Contractor culture that supports continuous learning, where employees and management share responsibility for ensuring that employees obtain the training and work experience they need to achieve their career goals, and to establish a Maintenance Contractor culture that supports innovation.

Goal 5: Effective People Strategy

To ensure that the Maintenance Contractor has an effective people strategy.

Goal 6: Progressive Employee/Employer Relations

To ensure that all managers and staff are aware of, and comply with, the provisions of the Labor Code of

the Philippines, and to provide an appropriate forum/mechanism for resolution of employee/employer issues.

(2) Human Resources Management Plan

The HR Management Plan should consist of at least the following sub-items:

1) Personnel Hiring Policy

The nature and complexity of the railway maintenance activities directly impact the skills and competencies of the personnel involved, revenue operation and the safety of the riding public. Hiring of maintenance personnel shall merit utmost consideration and scrutiny. The fundamental hiring policy is to recruit and attract, retain and motivate only the highly qualified applicants who, after a thorough pre-employment physical examination and educational assessment, are deemed as such.

The hiring of young graduates with excellent potential as evidenced by their personal scholastic records shall be given consideration and shall be subjected to a validation process. Engagement of applicants for non- technical slots like administrative and finance positions shall likewise be dealt with appropriately in line with the general objectives and strategy of the organization.

2) Personnel Termination Policy

The employer will not terminate the services of an employee except for a just cause or authorized causes as provided by law and subject to the requirements of due process.

3) Benefits Management Policy

The Maintenance Contractor measures benefits administration as tools that support both human resource strategies and competitive strategies. Other than the legally required benefits besides the basic wage or salary, such as retirement and health insurance, four fundamental roles characterize the benefits program: Protection Programs, Paid Time Off and Accommodation & Enhancement, Overtime Pay, and Night Shift Deferential Pay.

4) Compensation Schedule Policy

The administration of compensation and benefits is set against two desired outcomes - performance and the individual's needs for both personal and professional development.

5) Manpower Skills Pool Policy

The Maintenance Contractor maximizes its own talent pool and ensures its workforce has the right skills, know-how and mindsets to meet the challenges brought about by an effective railway maintenance system.

6) Human Resource Pool Policy

Human Resource Pool will undergo improvements in the area of workers' attitude and technical skills to meet the mission and goals of the Maintenance Contractor. This philosophy is embedded in the belief that interplay of business performance and personnel need for professional development will result to outstanding performance.

7) Job Requirement and Description Policy

The maintenance of pertinent factual information in the form of job descriptions in order to identify the work to be performed; the corresponding responsibilities relative to the different jobs in the organization and the requirements for performing the work and their corresponding frequency and scope. Job Descriptions and requirements should be based upon the nature of the work rather than on the individual currently performing the specific job.

(3) Training and Skills Development Plan

Technical Modules for the different AER Systems should be formulated to enhance the technical competency of the maintenance teams that work for the company and the community at large which are the direct beneficiaries of the kind of service and maintenance the company will make.

The Maintenance Contractor aims for a better, faster and more competitive and performing workforce through a Training and Skills Development Plan that will ensure that employees have the knowledge required for their respective jobs, improve morale and instill pride in the quality of workmanship.

Conduct of needs analysis and performance analysis to help determine the kind of training modules to offer and to identify the personnel who will avail of such program. Other techniques that will be used in determining training needs would include supervisors' reports, personnel records, management requests, observations, tests of knowledge and questionnaire surveys.

- The different departments are required to give training to further update and augment the skills of the new and present employees of the company. These refer to the technical requirements of the maintenance program. Funding will be allocated to these areas of concern.
- All employees that do not have extensive experience in their particular assignments shall undergo training. Likewise, refresher courses must be run internally in each section in the determined intervals or as defined by the section managers.
- The HR will coordinate with the respective sections in the performance appraisal, normally scheduled on a quarterly basis. The information in this activity will have impact on the Needs Analysis.

Training/Seminar schedules for the whole year will be properly scheduled to ensure that regular working routines are not compromised. Venues will be coordinated with other existing institutions here and abroad to avoid creation of separate training facilities and resources.

Supervisory and Managerial development is given equal priority by the Maintenance Contractor. This is an attempt to further improve current or future management performance by imparting knowledge, changing attitudes and increasing skills. Outside seminars, university related programs (MBA), and continuing educational programs are some examples.

The effectiveness of the training program and development plan will be evaluated in four categories of outcomes to determine the strengths and weaknesses of the program, the impact of the training on the participants and the organization and the cost and benefits.

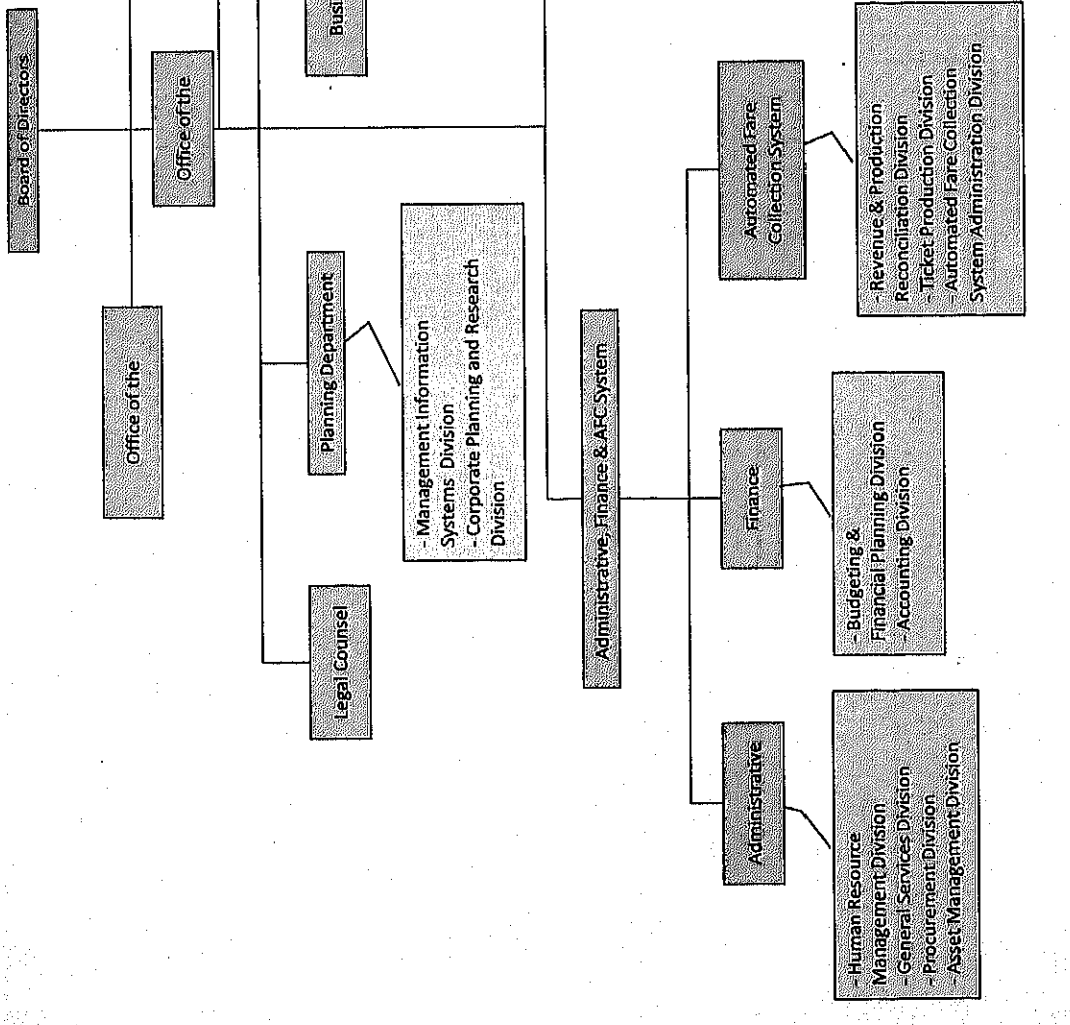
- Trainee's reaction to the programs- How did the participants react to the program?
- Determine whether the trainees/employees learned the principles, skills and factual information that they were supposed to acquire
- The impact of the training on work behaviors

- Improved results in terms of performance and productivity

9.2.3.2 Structure of Operation and Maintenance

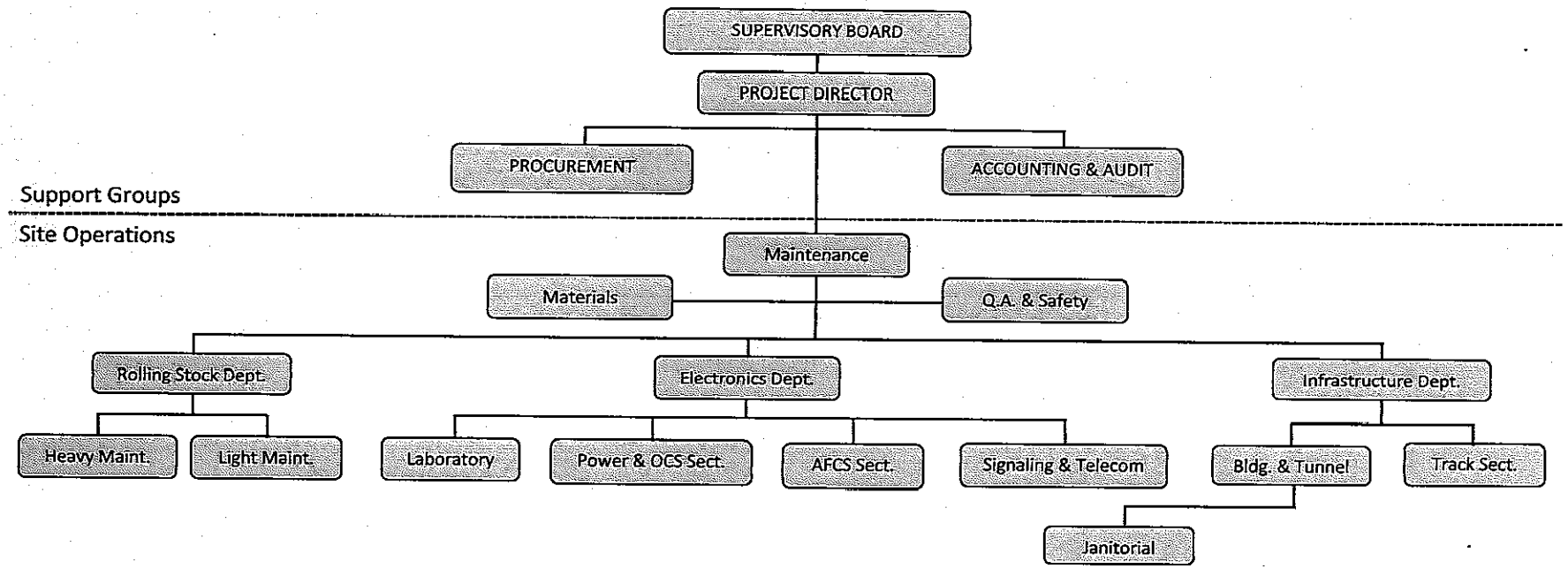
The Operator and the Maintenance Contractor's objective in selecting and developing the organization structure is to ensure that the organization will provide clear lines of formal communication and control, and effective informal communications (networking). The organization must also function smoothly both internally and in its relationship with its counterpart (LRC/Contractor) and the various Agencies that will be involved directly or indirectly with the project. It will clearly identify the functional requirements related to the management of this contract, it will provide the correct balance of management and operational staff, and the optimum numbers, categories and disciplines of staff to ensure the technical and managerial success of the maintenance activities for AER.

Accordingly, the Operator/Maintenance Contractor should take the guiding principle in its organization structure and adopt the concept of fully integrated teams. The entire organization could be subdivided into a Management/Administration Group and a Site Maintenance Group. The recommended functional structures are shown in the **Figure 9.2-3** for Operator/Supervisory Agency and **Figure 9.2-4** for Maintenance Contractor.



Source: JICA Study Team

Figure 9.2-3 Organization Chart of Operator / Supervisory Agency



Source: JICA Study Team

Figure 9.2-4 Organization Chart of Maintenance Contractor

9.3 O&M Cost for AER

The O&M cost for the AER was estimated based on the Operation plan envisaged in Chapter 6. The parameters used to determine the cost are the track length, number of stations, number of trains, train-km/year, number of RSS, etc.

Except for electrical power rates, the prices of each item were estimated using current unit prices of the existing railway system, in this case LRTA of Manila. The summary of O&M costs per year and per item is presented in **Table 9.3-1**.

Table 9.3-1 O&M Cost

unit: Mill pesos

Item/Year	2020	2025	2030	2035	2040
Manpower	**616.78**	**670.08**	**683.40**	**683.40**	**720.71**
Administration, OCC, fixed	111.40	111.40	111.40	111.40	111.40
Stations	95.85	95.85	95.85	95.85	95.85
Civil, Tracks	292.65	292.65	292.65	292.65	292.65
Rolling Stock	21.32	74.62	87.94	87.94	125.25
Power	20.00	20.00	20.00	20.00	20.00
Janitors	75.56	75.56	75.56	75.56	75.56
Spare Parts	**979.21**	**3,255.64**	**3,810.36**	**3,810.36**	**5,674.22**
Capital	626.25	2,493.59	2,948.63	2,948.63	4,477.55
Consumables	352.96	762.04	861.73	861.73	1,196.67
Power	**590.35**	**2,350.66**	**2,779.61**	**2,779.61**	**4,220.88**
Office Rental & Maintenance	**365.86**	**365.86**	**365.86**	**365.86**	**365.86**
Station Services (security)	**182.93**	**182.93**	**182.93**	**182.93**	**182.93**
Total	**2,735.13**	**6,825.16**	**7,822.16**	**7,822.16**	**11,164.60**

Source: JICA Study Team