Chapter 4
State of Technology and Challenges of Railway Sector

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4.1 State of Technology and challenges of Railway-related Fields

In this study, the Study Team conducted field surveys and interviews of railway companies, administrative entities, and related organizations regarding the state of technology and issues of various fields related to railway. The following are the results and challenges for the future.

4.1.1 Rolling Stock

This section will mainly cover the specifications of rolling stock and maintenance. The making of new rolling stock will be covered in "4.3 State of Related Private Sectors, Supporting Industries, and Issues."

(1) Current Status

1) Characteristics of Rolling Stock

In South Africa, railways are electrified using 3kV DC, 25 kV AC, and 50 kV AC. Suburban lines near big cities use DC as they were electrified at a relatively early period. The rural lines mainly use AC. The Iron Ore Line (Sishen–Saldanha section) uses 50 kV AC electrification, which is quite rare in the world. For this reason, various types and models of rolling stock are in use, including electric locomotives that can be used for various electrification methods and non-electrified sections, diesel electric locomotives, diesel locomotives, and electric multiple units (EMUs). DC motor is used mainly for the traction motor of locomotives and the motor cars of EMU; however, AC induction motor, which is the world standard today, is used for Series 19E and 15E electric locomotives.

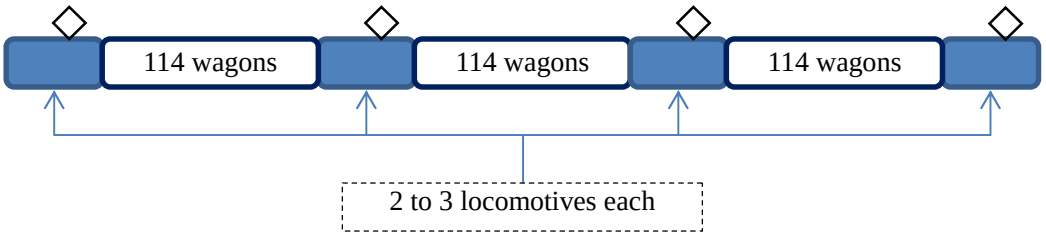
Both the freight trains and passenger trains of the South African National Railway use vacuum brake as the main braking system. It is an extremely old system, which was abolished and replaced by the existing automatic brake in Japan eighty years ago. In principle, since it is difficult to have strong braking power and high-speed brake response, the braking system has to be big in size, which is a drawback. Incidentally, even in the United Kingdom, the former colonial power, vacuum brake was widely used up to the 1970s.

However, automatic brake has been adopted by the long freight trains operating on the Iron Ore Line and Coal Line. Furthermore, improvement is being made to commuter trains. Automatic brakes are installed during their large-scale refurbishment (Upgrade, explained later).

On the other hand, the South African railway is known worldwide for its technology to use rolling stock with heavy axle load in long trains for mass transportation.

As an example, the Iron Ore Line opened for service in 1976 has a maximum permissible axle load of 30 tons, which is one of the highest in the world. Locomotives coupled in 3–4 units are allocated at multiple positions throughout the trainset. Except for the first locomotive, no drivers are onboard the other locomotives. Their operation is by multiple unit control, in which the driver in the first car operates the other locomotive units using a wireless remote control system.

Figure 4-1 shows the configuration of a freight train on the Iron Ore Line.



Source: Compiled by Study Team

Figure 4-1 Configuration of a Freight Train on the Iron Ore Line

The Coal Line also transports freight in mass in a similar manner. Table 4-1 shows the specifications of mainly freight cars used on the Iron Ore Line and Coal Line.

Table 4-1 Specifications of Freight Cars Used on the Iron Ore Line and Coal Line

Name of line	Iron Ore Line	Coal Line
Maximum axle load	30 tons	26 tons
Electrification	50kV AC	3kV DC or 25kV AC
Locomotive	Electric locomotives: Series 9E and 15E Diesel locomotives: Series 34D and 43D	Electric locomotive: Series 19E
Wagon weight	20 tons	20 tons
Maximum payload	100 tons	84 tons
Gross weight	120 tons	104 tons
Car body material	Carbon steel	Stainless steel (to prevent corrosion caused by the acid in coal)
Train configuration	5 Electric locomotives + 4 diesel locomotives + 342 wagons = 4 km in length	6 Electric locomotives + 200 wagons = 2.4 km in length

Source: Compiled by Study Team

By using the Scheffel bogie (one of the self-steering bogie types, developed by Mr. Scheffel), developed in South Africa in the 1970s, in these line sections, wear of the flange when a train navigates the curved sections can be cut to one-fifth. The effective and unique technology can reduce the cost of transporting heavy freight.

2) Maintenance of Rolling Stock

Except for the running inspection carried out by PRASA, the TFR and PRASA rolling stock is inspected and repaired by TRE under TRANSNET.

a) TRE (Transnet Rail Engineering)

TRE has 6 workshops and 132 depots throughout South Africa.

General Overhaul Program (GOP) and Mini Overhaul Program (MOP) are carried out at the six workshops.

In MOP, repair is carried out after removing the bogies, electric equipment, and mechanical

parts and dissembling the whole car. GOP is also a dismantling inspection. It is of a larger scale that involves replacement and upgrade of parts.

The frequency and implementation are different depending on the car type. The typical overhaul periods are as follows:

［Electric locomotives］
- GOP：12 year-cycle, takes approximately two months to overhaul
- MOP：6 year-cycle (3 years for Series 19E and 15E), takes approximately one month to overhaul

［EMU］
- GOP：Implement according to rolling stock condition (known as Condition Based Maintenance: CDM)
- Light Repair：Repair of the traction motor and some equipment units

An even larger scale of overhaul is called upgrade. Such large-scale refurbishment will reuse the under-frame and bogie but replace the whole car body and equipment with new ones to improve their performance. The upgrade from vacuum brake to automatic brake will also be carried out at this time.

As an example, when an EMU is being upgraded, the old car body will be dismantled and removed from the under-frame. Car body panels made of carbon steel sheets will be bolted together at several locations. The roof material will be attached to assemble a new car body. It is a simple method without using welding; however, the side sheathing of the car body cannot support heavy weight, making it imperative to have a heavy and strong under-frame. This is an old method. Figure 4-2 is an example that shows the assembly of the car body. Furthermore, upgrade includes replacement with an electric air compressor, making the main control circuit contactless, and changing the vacuum brake to automatic brake.

Source: Photo taken by Study Team

Figure 4-2　Assembly of EMU Car Body during Upgrade

Table 4-2 shows the inspection periods of locomotives. However, the periods are slightly different depending on the use conditions and car type.

Table 4-2 Types of Inspection for Electric Locomotives

Type of inspection	Cycle	Contents	Time required
A-Shed	1 month	Appearance inspection of car body Appearance inspection of equipment Cleaning	4 hours
B-Shed	6 months	Inspection items of A-Shed: Inspect condition of high voltage and wire connection Inspect oil	1 day
C-Shed	1 year	Inspection items of B-Shed: Change oil Calibration Calibrate meters Adjust brakes	2 days
D-Shed or MOP(Mini Overhaul Program)	6 years (3 years for Series 19E and 15E)	Overhaul by removing the electric equipment and mechanical equipment (including bogie) from the car body	1 month
D-Shed or GOP (General Overhaul Program)	12 years	Overhaul by removing the electric equipment and mechanical equipment (including bogie) from the car body Refurbishment Repainting of car body, etc.	2 months

(Note)"Shed" is used here as a type of inspection.
Source: Compiled by Study Team

b) PRASA

PRASA carries out running inspection of its commuter trains, that is, inspection of train cars in between their deployment for commercial operation at its own car depots. Table 4-3 shows the inspection periods.

Table 4-3 Inspection Items of Commuter Trains (Running Inspection)

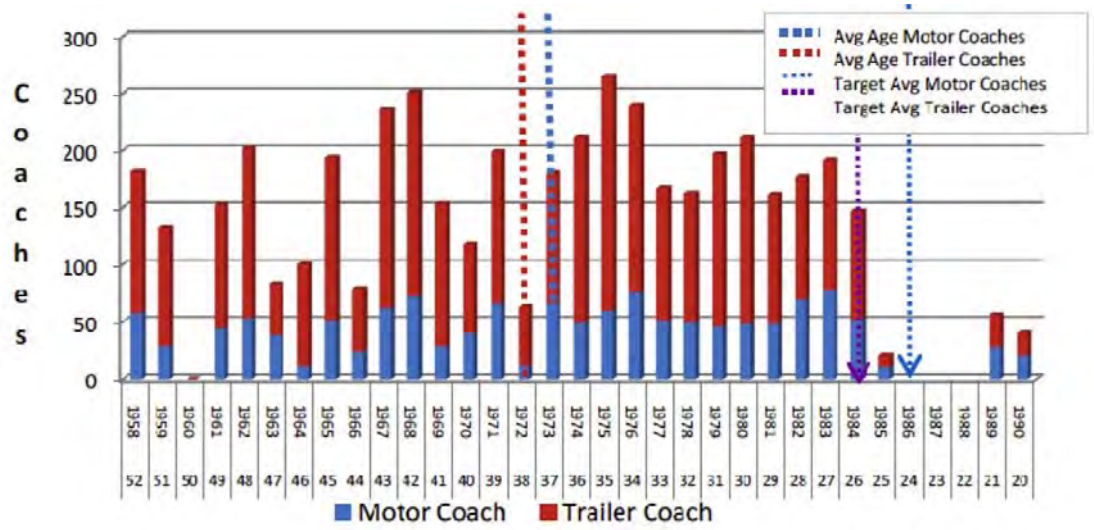
Inspection item	Period	Inspection contents	Duration
PSC (Passenger Service Comfort)	14 days	Oil, pantograph, seats	1.5–2 hours
Intermediate Shedding	28 days	Carbon brush of traction motor, motor generator, motor driven blower	3–6 hours
Full Shed	48–56 days	Rotating machines in general Braking equipment-related	6–9 hours

Source: Compiled by Study Team

(2) Issues

Similar to other areas, investment in railway rolling stock has been extremely limited for over twenty years in South Africa. As a result, the trains are outdated.

As shown in Figure 4-3, the average age of the EMU used for the PRASA commuter trains is 37–38 years. Most of the trains are over 26 years old. As the trains age, the frequency of malfunctions rises. It becomes more difficult to obtain parts for replacement. According to the interviews that the Study Team conducted at car depots, malfunctions mostly occur in electrical wiring, traction motor, and other rotating equipment. The reason is degradation caused by aging. As an example, since malfunctions occur frequently before the regular inspection period in Cape Town, the ratio of condition-based maintenance vs. regular inspection is extremely high, as much as 3: 1.



Source: PRASA Rolling Stock Fleet Renewal Programme, PRASA (2011)

Figure 4-3 Age Distribution of Commuter Trains Owned by PRASA

1) Difficulty in Obtaining Component Parts

Even when it is necessary to replace certain component parts during inspection, many of the electrical component parts are not manufactured in South Africa. It takes time for the imported parts to clear customs. Some of them may take up to several months to obtain. As time passes, some component parts may no longer be produced by the manufacturers. Thus, in order to ensure the operating condition of rolling stock, the railway operator has to stop using some train cars and remove their parts for use in other cars.

Some imported parts may also have problems. Originally, TRF uses traction motors manufactured by Siemens for its electric locomotives; however, it has purchased the less expensive traction motors from China for replacement. Since there are weaknesses in the structure, flashover occurs easily.

2) Decline in the Technical Level of Workers and Interruption in Technologies

Decline in the technical level of workers is a serious problem. Even basic tasks are prone to errors. For example, mistake in the installation of carbon brush in the traction motor of a locomotive may cause the train to break down.

Therefore, TRE established the School of Engineering (SOE) in main car depots to provide technical education to high school graduates based on department needs before the graduates are hired for the positions. PRASA also established educational facilities called Training Academy to enhance the skill level. However, due to the low wages compared to working in mines, all workplaces in the railway are having difficulty maintaining the skill level as even the skilled workers leave for other jobs.

On the other hand, the veteran engineers and skilled workers are entering retirement one after another. The shortage of successors raised concerns about the interruption of technology. It is necessary to provide basic education to new employees as well as strengthen the training of mid-level employees.

3) Frequent and Serious Failures of Rolling Stock

Although each workplace collects data on the malfunctions of each train car, the data have not been used effectively for analyzing the trend of failures as a whole and preventing the recurrence of malfunctions.

Table 4-4 shows train failures that resulted in serious accidents.

Table 4-4 Train Failures Causing Serious Accidents (TFR, April–June 2012)

Cause / Type of accident	Damaged axle	Brake failure	Coupler failure	Wear of wheel flange	Fire of high-voltage equipment
Train collision	-	-	-	-	-
Train derailment	3	3	2	1	-

Source: Fourth quarter report submitted by TFR to RSR

Table 4-4 shows that train derailments occurred frequently because of train failures. In particular, damaged axles and wear of wheel flange are not failures that occur suddenly. There should have been some symptoms or changes in dimensions/shapes beforehand. It is possible that there is quality issue in some of the component parts or problem in maintenance technology, making it not possible to detect defects during regular inspection.

As explained above in 1) to 3), the frequent failures caused by aging rolling stock, decline in work skills, and lack of capability to analyze data on train failures are some of the issues of rolling stock. Among them, the issue of aging rolling stock will be resolved by the planned procurement of large number of trains in the future. The use of AC electric motors and electronic control circuit in the new-type trains is expected to reduce the high-maintenance parts.

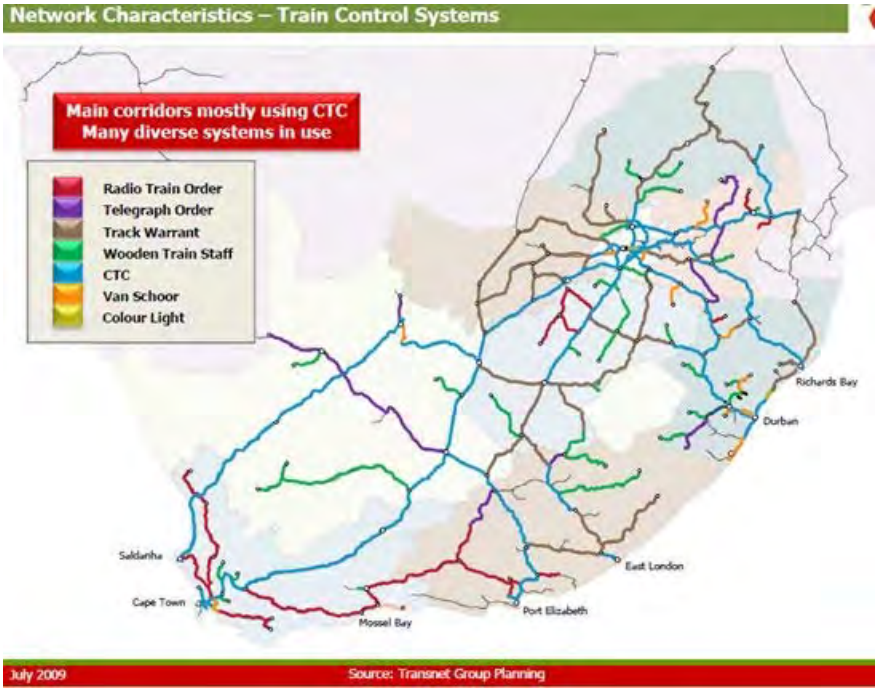
On the other hand, the new trains will no longer have some mechanical parts, especially the control circuitry. Since it is difficult to understand the operation through instinct, it makes it increasingly necessary to understand their mechanism correctly. At the same time, movable parts that are important to safety, such as wheels, axles, and brakes, will remain. Even though the new model rolling stock is said to require less maintenance, without correct understanding of the new technologies and enhanced ability for analyzing malfunctions, the newly introduced trains will be compromised by improper maintenance, making it difficult to provide safe and reliable services. Therefore, the importance of education and training will not change in the least.

4.1.2 Current State of Signaling Technology and Issues

(1) Current State

The signal sections account for 50% of the South Africa railway network (22,000 km). Most of them use color light signals, approximately 25% of them are mechanical signals. For the color light sections, 6,200 km have CTC control and 600 km have station control.

As shown in Figure 4-4, many different types of block systems are in use. Besides the automatic block system, the radio type, telegraph type, token type, and other block systems are being used.



Source: TRANSNET material

Figure 4-4 Block Systems

Table 4-5 shows the differences and characteristics of signaling systems in major line sections.

The TRANSNET Coal Line uses the 3-aspect color signal system. Under this system, many crossovers had to be constructed on station premises and between stations to facilitate single-track parallel operation. The inefficiency of such operation became known in the past. By the way, there is a historical reason for the unique multi-aspect signal system in South Africa as it was installed to eliminate inefficiency by using speed control at locations with turnouts.

The Metrorail lines of PRASA and the general freight lines of TRANSNET (sections besides the Coal Line and Iron Ore Line) have the same signal system. However, since the braking distances of the two types of trains are different, their buffer distances for preventing overrun are also different. Metrorail added flickering function to the yellow and red aspects and increased the number of indicators.

The multi-aspect signal system and the flickering aspect in Metrorail line sections are signaling systems unique to South Africa; they are different from the Japanese system.

Table 4-5 Characteristics of Signaling Systems in Major Sections

Section	Characteristics	Remarks
TRANSNET (Coal Line)	- 3-aspect color signal system (G-Y-R) - Multi-aspect color signal system (G-R-Y-Y) (Figure 4-5) - Turnout on the mainline 1/20 [speed limit 75 km/h] (G-Y aspect) - Turnout on the mainline 1/12 [speed limit 30 km/h] (Y-Y aspect) - Gradient 1/160 (1 m difference in height for horizontal distance of 160 m)  Source: Photo taken by StudyTeam Figure 4-5 Multi-aspect Signal System	- Drawback of 3 aspect color signal system: Cannot distinguish the inward of a Y aspect whether it is an R aspect or a Y aspect - Inefficiency in operation: Crossover between the up line and down line - Difficult to secure braking distance: W-Y aspect/Y aspect/R aspect (W: white light)
TRANSNET (Iron Ore Line)	- Single track - 3-aspect color signal system - Turnout on the mainline 1/12 [speed limit 30 km/h] - Has passing side line [90-km interval: Length 4 km]	- Mainline indication of station yard signals: W-G aspect and W-Y aspect - Branch siding indication: Y-W(L)/Y-W(R) aspect
TRANSNET (General Freight Lines)	- 3-aspect color signal system - Multi-aspect color signal system: R-B aspect (Emergency Aspect) (B: Blue light) Install Shunting signal / Route indicator - Install overlap section (over 275 m) or safety siding	- Share with passenger trains - Also use mechanical signal system

PRASA (Metrorail Lines)	- 3-aspect color signal system - Multi-aspect color signal system (Figure 4-6): R-B aspect(Emergency Aspect) Y-flash aspect, R-flash aspect Install Shunting signal / Route indicator - Install overlap section (over 110 m) or safety siding  Source: Photo taken by Study Team Figure 4-6 Multi-aspect Color Signal System	- Indication similar to the one used in general freight line sections - Shorten overlap sections to improve headway - Y-flash aspect: Indicate the existence of a turnout inward of the G aspect - R-flash aspect: Release emergency aspect
GAUTRAIN	- Cab signal with wayside signal - Automatic Train Protection (ATP)	- Use standard gauge - With train protection function

(Note) Emergency aspect: Despite the red aspect, if the blue aspect lights up, the train can proceed gradually after confirming with the dispatcher. There is a function to notify the driver in advance by turning the red aspect on and off when releasing the emergency aspect.

Source: Study Team/ Railway Signaling & Telecommunications in South Africa 1998 IRSE

The major railway operators in South Africa are TRANSNET, PRASA, and GAUTRAIN. Although the environment faced by each operator and the history of their establishment are different, the Study Team will look at PRASA at this time since it faces issues that are also common to the other operators.

1) Aging

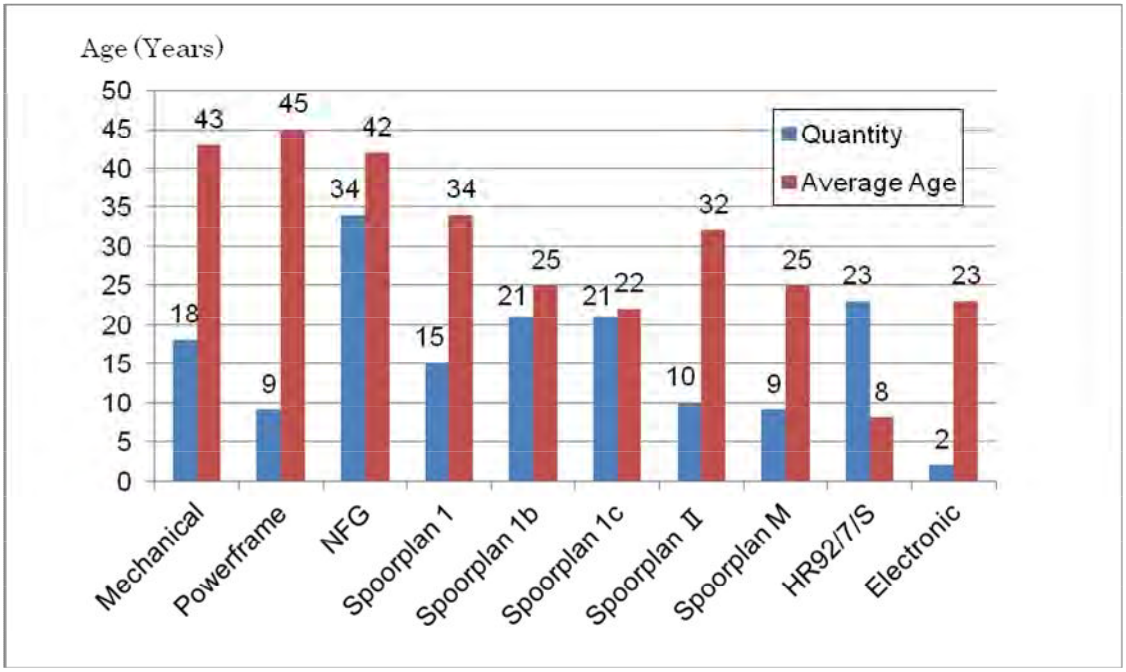
To show the actual condition of how much signaling facilities have aged, the Study Team used the interlocking devices (total 162 sets) for ensuring the safety of trains operating in the Metrorail sections in four areas (Southern Gauteng/ Northern Gauteng/ Western Cape/ Durban) operated by PRASA as an example.

Figure 4-7 shows the average ages of various interlocking devices by type from their installation until the present time.

As of 2012, the average operation year of the mechanical interlocking device, which accounts for 38% of all interlocking devices, is 46 years. The average operation year of the hybrid relay interlocking device, which accounts for 47% of all interlocking devices, is 30 years.

In order words, 85% of the interlocking devices are old and are operating under a condition that

has far exceeded their design life. (In the case of Japan, the hybrid type is about 20 years and the all relay type is about 30 years.)



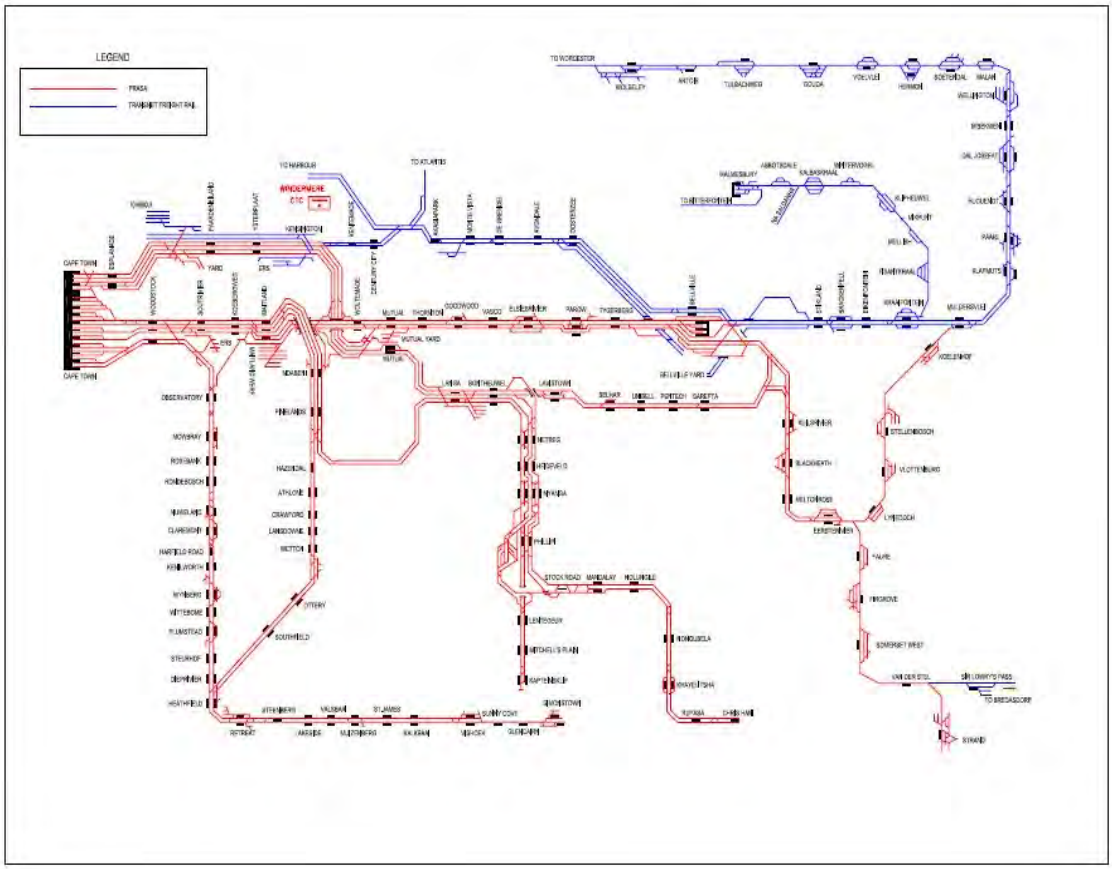
Source: Re-Signaling Implementation Master Plan for SARCC 2009 HERA INFRASTRUCTURE

Figure 4-7 Interlocking Types and Average Ages (Metrorail)

Compared to the countries with advanced railway technology, the PRASA trains generally have low punctuality and high cancellation rate. The safety of train operation continues to deteriorate in recent years.

2) Decline in Transport Quality

Compared to the Metrorail in other areas, the Metrorail in the Cape Town area is said to have adequately fulfilled its function as an urban railway. Figure 4-8 shows a route map of the Metrorail in the area.



Source: PRASA material

Figure 4-8 Metrorail Route Map in Cape Town Area

Using this Cape Town area as a representative example, the Study Team first obtained an overview of facility failures and their effects on train operation, and then focus on the causes of facility failures, failure restoration, and restoration time in order to understand the actual technical capability of maintenance and the failure restoration level. Based on this understanding, the Study Team will review the issues common to all railways in South Africa.

The Study Team obtained a general idea of the Metrorail in Cape Town area based on the weekly train operation data shown in Table 4-6 and the weekly reported signal incidents data (August 2–8, 2012) shown in Table 4-7.

Of the 3,840 scheduled trains in weekly train operation, 15 were cancelled, 527 were late (14% of the total number of trains), and the total time of delay was 6,877 minutes. Even from the perspective of transport quality, which is premised on punctual operation, the situation is less than desirable.

The main reasons causing the delay are rolling stock-related (183 delayed trains and total delay time of 2,713 minutes), train operation-related (86 delayed trains and total delay of 1,209 minutes), and signaling facilities-related (77 delayed trains and total delay of 846 minutes).

Table 4-6 Weekly Train Operation Data

Metrorail Western Cape: Time Keeping of Metro Trains
Week: 2 to 8 August 2012

	% Trains on time						Direct			Consequential			Total			Manageable Delays & Cancellations		Direct			Consequential			Total			Not manageable - factors beyond Metrorail control
Date	MP	AP	Ave	Delays	CX		Train	Min	CX	Train	Min	CX	Train	Min	CX			Train	Min	CX	Train	Min	CX	Train	Min	CX	
GRAND TOTAL						Rolling Stock	159	2351	11	24.6	362	2	183	2713	13		Passenger Related	0	0	0	0	0	0	0	0	0	
						Signals	62.6	696	0	14.4	150	0	76.9	846	0		Cable Theft	0	0	0	0	0	0	0	0	0	
						Electrical	13	356	1	0	0	0	13	356	1		Vandalism / Sabotage	0	0	0	0	0	0	0	0	0	
						Perway	27.9	346	0	0	0	0	27.9	346	0		Robbery / Assults	0	0	0	0	0	0	0	0	0	
						Train Ops	82.8	1161	1	3	48	0	85.8	1209	1		Obstructions	0	0	0	0	0	0	0	0	0	
						Customer Services	68.6	631	0	2.54	23	0	71.2	654	0		Accidents	0	0	0	0	0	0	0	0	0	
						Protect. Serv	17.6	274	0	11	162	0	28.6	436	0		Legal Compliance (E.g. Person struck by train, suicides, Level crossing accidents)	3.35	70	0	0	0	0	3.4	70	0	
						Transnet Freight Rail	6	91	0	0	0	0	6	91	0		Metrorail Agreed events / Security Contracts	0	0	0	0	0	0	0	0	0	
						Infra Telecoms	0	0	0	0	0	0	0	0	0		Technical Operations Contractors	0	0	0	0	0	0	0	0	0	
						Facilities	0	0	0	0	0	0	0	0	0		Mandatory Mods.	0	0	0	0	0	0	0	0	0	
						Shosholoza-Meyl	1	6	0	0	0	0	1	6	0		ESCOM Failures	0	0	0	0	0	0	0	0	0	
Total	% Trains on time					Other/ Planned Maintenance	8.79	220	0	0	0	0	8.79	220	0		Police / Secutity Actions	0	0	0	0	0	0	0	0	0	
For the week	MP	AP	Ave	Delays	CX												Act of Nature	20.9	341	0	0	0	0	21	341	0	
	74.3	91.8	86.2%	527	15												Revised Service	167	1567	0	0	0	0	167	1567	0	
Trains Scheduled	3840						447	6,132	13				503	6,877	15			24	411	0	0	0	0	24	411	0	

Source: Metrorail Cape Town material

Table 4-7 Weekly Reported Signal Incidents Data

Date	Time				Reaction Time			Station	Equipment	Keyword	"U/F/ KSR"	Remarks	Delays		Trains	Responsible Department	Fault	Empac	Unnecessary			
	Time Out	Reported to Technician	Arrived on site	Repaired	Travel Time	Time to Repaired	Outage Time						Trains	Minutes	Cancel		Number	Number	Remarks	Trains	Minutes	Cancel
2-Aug-12	4:20	7:00	7:10	7:11	0:10	0:01	2:51	Bay Junction	1946G	Signal	U	RG lamp dead - Replaced lamp	0	0	0	Signals	08/15	12-003418	S. Maloney			
2-Aug-12	5:40	5:43	6:10	6:45	0:27	0:35	1:05	Bellville	4011W	Points	U	Cleaned microswitch contacts	16	177	0	Signals	08/16	12-003420	Aya			
2-Aug-12	6:14	6:18	6:40	6:54	0:22	0:14	0:40	Retreat	3240G	Signal	KSR	Testede in order - Kriel	0	0	0	Signals	08/17	12-003422	Lefa			
2-Aug-12	6:26	6:30	9:00	23:59	2:30	14:59	17:31	Vlottenberg	Van schoor	Van schoor	U	Faulty counter	0	0	0	Signals	08/18	12-003423	Sipho			
2-Aug-12	6:50	6:57	7:20	7:40	0:23	0:20	0:50	Nyanga	4132G	Signal	F	Replaced blown 1.6 amp fuse	2	25	0	Signals	08/19	12-003424	Andiswa			
2-Aug-12	6:48	6:50	6:50	7:15	0:00	0:25	0:27	Bellville	4501W	Points	U	Adjust blade tension	0	0	0	Signals	08/20	12-003425	Aya			
2-Aug-12	10:38	10:47	11:15	15:30	0:28	4:15	4:52	Kuils River	B8640T	Track cct	U	Faulty fuse holder on outgoing panel	2	30	0	Signals	08/22	12-003428	Aya			
2-Aug-12	11:57	12:00	12:10	13:50	0:10	1:40	1:53	Elsies River	8619W	Points	KSR	Tested in order - Malusie	1	6	0	Signals	08/24	12-003430	Barn			
2-Aug-12	13:33	13:35	13:50	14:00	0:15	0:10	0:27	Faure	13T	Track cct	U	Blown RX fuse	0	0	0	Signals	08/25	12-003431	Francke			
2-Aug-12	15:47	16:02	16:18	16:25	0:16	0:07	0:38	Hazendal	9866G	Signal	U	HG aspect dead - Replaced lamp	1	6	0	Signals	08/26	12-003432	Khusta			
2-Aug-12	17:52			18:06	0:00	0:14	0:14	Eersterivier	A130T	Track cct	KSR	Cleared self - Jackson	0	0	0	Signals	08/28	12-003434	Tco			
2-Aug-12	21:25	21:30	21:37	21:40	0:07	0:03	0:15	Blackheath	Control Panel	Interlocking	U	Control panel dead - Replaced fuse	0	0	0	Signals	08/29	12-003435	T. Francke			
3-Aug-12	5:54			6:01	0:00	0:07	0:07	Salt River	6540G	Interlocking	KSR	Cleared after cancellation - Chris	0	0	0	Signals	08/32	12-003438	Tco			
3-Aug-12	6:00			6:03	0:00	0:03	0:03	Salt River	1021W	Points	KSR	Cleared self - Chris	0	0	0	Signals	08/33	12-003439	Tco			
3-Aug-12	6:27	6:57	7:35	9:12	0:38	1:37	2:45	Bontheuwel	1703T	Track cct	U	Track cable rusted off	0	0	0	Signals	08/34	12-003440	Andiswa			
3-Aug-12	9:29			9:33	0:00	0:04	0:04	Bellville	5462G	Interlocking	KSR	Cleared after cancellation - Christine	1	6	0	Signals	08/37	12-003444	Tco			
3-Aug-12	12:39	12:53	13:15	13:45	0:22	0:30	1:06	Bontheuwel	1703T	Track cct	KSR	Cleared after cancellation - Burger	0	0	0	Signals	08/38	12-003446	Anele			
3-Aug-12	16:03			16:07	0:00	0:04	0:04	Philippi	6352G	Interlocking	KSR	Cleared after cancellation - Burger	0	0	0	Signals	08/39	12-003447	Tco			
3-Aug-12	16:03			16:06	0:00	0:03	0:03	Maitland	6744G	Interlocking	KSR	Cleared after cancellation - Plaatjies	0	0	0	Signals	08/40	12-003448	Tco			
3-Aug-12	17:17			17:20	0:00	0:03	0:03	Muizenberg	3740G	Interlocking	KSR	Cleared after cancellation - Tiaan	0	0	0	Signals	08/41	12-003449	Tco			
3-Aug-12	17:24			17:27	0:00	0:03	0:03	Bellville	4242G	Interlocking	KSR	Cleared after cancellation - Engelbrecht	0	0	0	Signals	08/42	12-003450	Tco			
4-Aug-12	5:24	5:27	5:55	6:15	0:28	0:20	0:51	Firgrove	3G	Signal	F	Lubricate slides	1	6	0	Signals	08/45	12-003453	T Franke			
4-Aug-12	9:20	9:25	9:50	11:05	0:25	1:15	1:45	Stellenbosch	01T	Track cct	U	Fuse blown	0	0	0	Signals	08/47	12-003455	T Franke			
4-Aug-12	11:20	11:35	13:20	13:50	1:45	0:30	2:30	Philippi	4932G	Interlocking	U	Fuse blown	6	82	0	Signals	08/48	12-003457	Khusta			
4-Aug-12	11:50	12:00	12:30	13:00	0:30	0:30	1:10	Philippi	A4966T	Track cct	U	Loose wire in trackbox	0	0	0	Signals	08/49	12-003458	Khusta			
4-Aug-12	12:50	12:55	13:40	14:29	0:45	0:49	1:39	Wetton	A6140T	Track cct	U	Broken wire under trackbox	0	0	0	Signals	08/50	12-003459	J James			
6-Aug-12	5:15	5:26	6:05	6:30	0:39	0:25	1:15	Bay Junction	2144G	Interlocking	U	Replaced BcZ unit	2	17	0	Signals	08/52	12-003462	P v staden			
6-Aug-12	6:50	6:55	7:25	7:44	0:30	0:19	0:54	Wetton	A6040T	Track cct	U	Replaced TR	4	26	0	Signals	08/54	12-003465	J James			
6-Aug-12	7:32	7:35	7:45	9:10	0:10	1:25	1:38	Fishoek	4562T	Track cct	U	Loose track cable in trackbox	1	15	0	Signals	08/55	12-003466	Cassiem			
6-Aug-12	8:35	8:40	9:06	9:07	0:26	0:01	0:32	York Rd	Booms	Road Protection	U	Adjust m/switch	5	86	0	Signals	08/58	12-003469	Cassiem			
6-Aug-12	8:58			9:01	0:00	0:03	0:03	Bellville	1262G	Interlocking	KSR	Cleared after cancellation - Tiaan	0	0	0	Signals	08/61	12-003472	Tco			
6-Aug-12	9:43	9:47	10:10	10:20	0:23	0:10	0:37	Woodstock	89W	Points	U	Replaced snubbing unit	1	16	0	Signals	08/62	12-003473	S Maloney			
6-Aug-12	9:33	9:37	10:20	11:45	0:43	1:25	2:12	Eersterivier	27W	Points	U	Replaced m/switch	3	18	0	Signals	08/63	12-003474	Sipho			
6-Aug-12	15:17	15:25	15:40	15:50	0:15	0:10	0:33	Maitland	6640G	Signal	U	Replaced lamp (DG)	0	0	0	Signals	08/66	12-003477	Barn			
6-Aug-12	18:33	18:35	18:40	18:45	0:05	0:05	0:12	Cape Town	117W	Points	U	Fuse blown	0	0	0	Signals	08/67	12-003478	J Stighling			
6-Aug-12	18:45	18:46	18:55	19:00	0:09	0:05	0:15	Woodstock	89AW	Points	KSR	Tested in order - Hantie	5	74	0	Signals	08/68	12-003480	J Stighling			
6-Aug-12	18:55			19:03	0:00	0:08	0:08	Newlands	3603W	Points	KSR	Cleared self - Flippie	0	0	0	Signals	08/69	12-003481	Tco			
6-Aug-12	19:10	19:17	20:00	20:14	0:43	0:14	1:04	Bontheuwel	3766G	Signal	U	Replaced TR (Ants)	0	0	0	Signals	08/70	12-003482	Wani			
6-Aug-12	20:00	20:07	21:40	21:50	1:33	0:10	1:50	Philippi	5515W	Points	U	Tighten loose barrel nut	0	0	0	Signals	08/71	12-003483	Wani			
7-Aug-12	3:47	3:50	4:15	4:25	0:25	0:10	0:38	Cape Town	89AW	Points	U	Cleaned snaplock contacts	5	43	0	Signals	08/73	12-003485	J Stighling			
7-Aug-12	9:20			9:30	0:00	0:10	0:10	Diep River	2142G	Interlocking	KSR	Cleared after cancellation - Burger	2	19	0	Signals	08/76	12-003489	Tco			
7-Aug-12	9:40	9:45	10:05	10:15	0:20	0:10	0:35	Eersterivier	FSDT	Interlocking	U	Reset	0	0	0	Signals	08/77	12-003490	Sipho			
7-Aug-12	11:48	11:50	11:55	12:00	0:05	0:05	0:12	Eersterivier	27W	Points	KSR	Tested in order - Van der Merwe	0	0	0	Signals	08/78	12-003492	Sipho			
7-Aug-12	16:56			16:58	0:00	0:02	0:02	Bellville	2640G	Interlocking	KSR	Cleared after cancellation - Christine	0	0	0	Signals	08/82	12-003497	Tco			
7-Aug-12	17:46			17:50	0:00	0:04	0:04	Langa	515W	Interlocking	KSR	Cleared after cancellation - Visser	0	0	0	Signals	08/83	12-003498	Tco			
7-Aug-12	17:06			17:08	0:00	0:02	0:02	Bellville	2640G	Interlocking	KSR	Cleared after cancellation - Christine	0	0	0	Signals	08/84	12-003499	Tco			
7-Aug-12	19:00	19:01	19:22	19:25	0:21	0:03	0:25	Eersterivier	126G	Interlocking	KSR	Tested in order - Neels	0	0	0	Signals	08/86	12-003501	Wani			
8-Aug-12	5:30	5:32	6:10	7:05	0:38	0:55	1:35	Eersterivier	FSDT	Interlocking	U	Reset FSDT	4	50	0	Signals	08/91	12-003507	T Franke			
8-Aug-12	7:02	7:05	7:10	7:18	0:05	0:08	0:16	Langa	515W	Points	KSR	Tested in order - Herselman	10	99	0	Signals	08/92	12-003508	Khusta			
8-Aug-12	7:14			7:17	0:00	0:03	0:03	Bellville	4140G	Interlocking	KSR	Cleared after cancellation - Johnson	3	19	0	Signals	08/93	12-003509	Tco			
8-Aug-12	7:20			7:23	0:00	0:03	0:03	Bellville	2640G	Interlocking	KSR	Cleared after cancellation - Johnson	0	0	0	Signals	08/94	12-003510	Tco			
8-Aug-12	7:36			7:40	0:00	0:04	0:04	Maitland	7162G	Interlocking	KSR	Cleared after cancellation - Nandi	2	16	0	Signals	08/95	12-003511	Tco			
8-Aug-12	15:38			15:40	0:00	0:02	0:02	Bellville	5462G	Interlocking	KSR	Cleared after cancellation - Christine	0	0	0	Signals	08/99	12-003517	Tco			
8-Aug-12	16:48			16:50	0:00	0:02	0:02	Bellville	1262G	Interlocking	KSR	Cleared after cancellation - Christine	0	0	0	Signals	08/100	12-003518	Tco			
8-Aug-12	16:55			16:57	0:00	0:02	0:02	Bellville	2640G	Interlocking	KSR	Cleared after cancellation - Ilene	0	0	0	Signals	08/101	12-003519	Tco			
8-Aug-12	18:23	18:24	18:47	19:00	0:23	0:13	0:37	York Rd	Booms	Road Protection	KSR	Tested in order - Lourens	0	0	0	Signals	08/102	12-003520	Lefa			
												56	77	836	0							

Source: Metrorail Cape Town material

Including the main section and three branch sections, the signaling depot has 96 members. They are responsible for the maintenance of signaling facilities (43 interlocking stations) in sections of approximately 250 km (including mechanical signal sections of 35 km).

3) Number of Incidents and Main Causes

Table 4-8 classifies the incidents of signaling facilities (56 incidents) by cause.

Table 4-8 Number of Incidents and Main Causes

Item	Incident	Cause
Signal	7	Burnt out light bulb, fuse blowout, no oil in machine, transformer malfunction, etc.
Switch	13	Bad contact, locking failure, switch failure
Track circuit	10	Cable erosion/loose connection, fuse blowout, wear and tear of relay points
Interlocking device	23	Bad route setting, fuse blowout
Grade crossing, etc.	3	Gate barrier malfunction

Source: Compiled by Study Team

It is true that the facilities are old judging from the failure contents of the signal, switch, track circuit, and grade crossing but most of the failures were due to insufficient maintenance. Essentially, the defective items should have been identified during regular inspection. They should have been probably adjusted, repaired, and replaced. In reality, however, these defects might have been discovered for the first time after the incidents occurred. It is difficult to explain, given the maintenance staff system mentioned above, why regular inspection has not been carried out properly to deal with these rampant failures when the regular maintenance plan is being implemented.

On the other hand, failures in interlocking devices are probably caused by the old equipment, based on the phenomena.

In addition, there are many squatter areas along the tracks. Thirty-two incidents of damaged signal boxes and grade crossing gates, and theft of signal cables occurred, which affected train operation considerably. Figure 4-9 shows one measure to prevent theft.

Source: Photo taken by Study Team

Figure 4-9 Theft Prevention Measure

4) Delay in Restoration from Failures

Next, by understanding the actual condition of restoration from failures, the Study Team determines the technical capability of the maintenance organization and the system for failure

response. The failure restoration time is the total of the time required to reach the site where the failure occurs and the time to repair and restore. In particular, if the Study Team only looks at the failures of switches and track circuits, which greatly affect train operation, the Study Team sees the following situation:

Among the incidents of switch failure, the maximum restoration time for repair works, such as adjustment and replacement of parts, is 113 minutes (repair 100 minutes) and the average time is 75 minutes (repair 40 minutes). The maximum restoration time for track circuit is 292 minutes (repair 255 minutes) and the average restoration time is 96 minutes (repair 66 minutes).

Since restoration from failures is taking long time, it is difficult to say that maintenance skills have been mastered through the daily maintenance works.

(2) Challenges

1) Present Challenges

The technical challenge for the moment is to step up education and training with the objective to master the skills necessary for carrying out total function inspection, individual check, adjustment, and repair of switches and track circuits in the maintenance of machinery and equipment at the existing work sites.

Furthermore, it is advisable to upgrade immediately the interlocking devices, which are the core element for ensuring safe train operation. However, due to the rampant occurrence of failures caused by old equipment, it is desirable to provide re-education and on-site training of interlocking function inspection to enable diagnosis of the causes of failures and their respective treatments.

2) Future Challenges

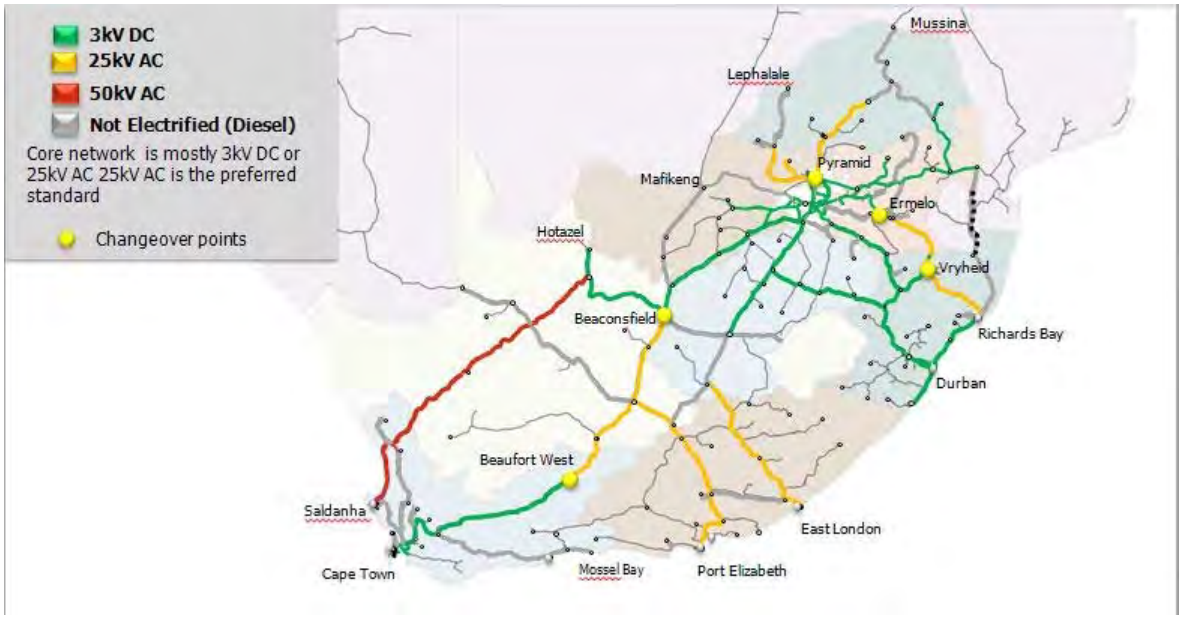
There was a long time since 1990 that no large-scale facility investment was made and technical transfer was lagging. Under such circumstances, it is necessary to quickly educate and train personnel to take charge of the modernization of the signaling and telecommunications facilities and the maintenance afterwards. Domestic education and training programs as well as education and training programs with overseas assistance shall be utilized to implement the projects for the modernization of facilities that have been gathering momentum since FY 2012. To train all personnel, it is necessary to implement an education and training program to train the leader class and then have the trained leaders to provide education and practical skills training to workplace staff at education and training centers. To enable the staff to master the new technologies and the maintenance skills required for maintaining the facilities through practical skills training is an urgent and important task.

4.1.3 Electric Power

(1) Current State

1) Feeding Methods

South Africa uses three types of feeding methods for its electrified lines. Most of the feeding sections use the 3kV DC feeding system, totaling approximately 5,700 km in length. In addition, approximately 2,500 km of feeding sections use the 25kV 50Hz AC feeding method and 861 km of feeding sections use the 50kV 50Hz AC feeding method, which is rare in the world. Figure 4-10 is a map of the feeding systems. Only the Iron Ore Line has 50kV AC sections, spanning the distance from Sishen in the inland to Saldanha. The 3kV DC feeding system is mainly used by the PRASA Metrorail in the suburbia of big cities. The 25kV feeding system is used by the Coal Line and the long-distance sections between cities. Shosholoza Meyl goes through the 3kV DC and 25kV AC feeding systems when operating in the Johannesburg–Cape Town section.



Source: TRANSNET material

Figure 4-10 Map of Feeding Systems

The electrification of South African railways started in 1926 with 3kV DC. Direct current electrification was the norm until the switch to alternate current in the 1970s. The current electrification systems were established by the 1980s. The DC substations, AC substations, and overhead contact lines are all facilities that have been used for over forty years since installation.

Table 4-9 gives a summary of the three types of feeding systems. The 3kV DC feeding system is a standard feeding system used by various countries in the world. Compared to the 1.5kV DC feeding system in Japan, the 3kV DC feeding system has many merits, such as little electricity loss, long interval between substations, and so on.

The 25kV AC is also a standard feeding system used by many countries in the world. It is used for the Shinkansen high speed lines in Japan.

The 50kV AC feeding system is a system with few parallels in the world. It is used by the Black Mesa and Lake Powell (BM&LP) Railroad in the United States to transport freight from the mines. This feeding system has the advantage of being able to transport heavy freight with large axle load using little load current.

Table 4-9 Summary of Various Feeding Systems

Item	3kV DC substation	25kV AC substation	50kV AC substation
Feeding voltage	3kV	25kV	50kV
No-load voltage	3.3kV	27.5kV	55kV
Receiving voltage	88–132kV	88–132kV	275–440kV
Continuous output current	1,500A	800A	800A
Feeding transformer	4,950kVA	20MVA	40MVA
Rectifier	4.5MW	None	None
Interval between substations	8–21 km	20–30 km	140 km

Main railway lines	Metrorail	Coal Line GAUTRAIN	Iron Ore Line
Characteristics	: International standard for DC feeding : Low voltage : Small insulation distance : Large current : Thick wayside cables	: International standard for AC feeding : High voltage compared to DC : Large insulation distance : Small current compared to DC : Thin wayside cables	: Rare feeding system in the world : High voltage : Large insulation distance : Small current : Thin wayside cables

Source: Compiled by Study Team

2) Facilities

Although TRANSNET and PRASA, the major railway operators in South Africa, use different trains, they share the use of some railway facilities. Here is an example of the current state of a 3kV DC substation. The Wolmerton Substation in the suburb of Pretoria was built in 1969. It is old because over forty years have passed since its construction. The receiving voltage is 88kV. The transformer used for the rectifier was made by AEG in 1969. The primary AC circuit breaker was just replaced in July 2012. The rectifier is an indoor open-type 4.5 MW silicon rectifier. The transformer for the rectifier was installed at the same time. The high-speed circuit breaker for feeding electricity to various directions is an open-air type made by Secheron. Figure 4-11shows the indoor facilities. The maximum train density for both the up and down lines in this substation section is about 40 trains/hour during the morning and evening rush hours

(a) Silicon Rectifier

(b) High-speed Open Air-type DC Circuit Breaker (HSCB)

Source: Photos taken by Study Team

Figure 4-11 Indoor Facilities of a DC Substation

Figure 4-12 is an example of the 25kV AC substation. This substation was constructed in 1982. It has been in use for over forty years. The Study Team could see from the nameplate of the feeding transformer that the transformer was made by GE in South Africa following the British Standard.

(a) Transformer for AC Substation (b) Transistor Nameplate

Source: Photos taken by Study Team

Figure 4-12 Transformer at an AC Substation

The overhead contact lines along the railway line were installed in the same period when the substation was constructed. Therefore, the 3kV DC feeding sections were built by the 1970s and the 25kV AC feeding sections were built in early 1980s. Both feeding sections have been in use over forty years. They are as old as the substation facilities. However, due to cable theft and other reasons, some facilities have been replaced in the past. Figure 4-13 shows the feeder cables.

(a) DC Feeding Section (b) AC Feeding Section

Source: Photos taken by Study Team

Figure 4-13 Feeding Sections along Railway Line

3) Maintenance

In terms of the maintenance system, the maintenance teams spread out in various parts of South Africa have prepared maintenance manuals based on international standards, South African standards, and TFR standards for performing preventive maintenance. Despite the availability of maintenance manuals for various facilities, they are manuals for regular inspection only. TRANSNET employs 6,000–7,000 people nationwide. It is providing training for inspection and maintenance personnel. One team is consisted of 15 people and it is responsible for 140 km on the average. For important line sections, such as the Coal Line, TRANSNET is taking measures by either reducing the distance of the section per team or increasing the number of people in a team.

The main units of equipment in the TRANSNET substations are managed, refurbished, and replaced based on a life cycle of 25 or 50 years. Such tasks are contracted out to companies performing maintenance for TFR.

In the one year and two month period from November 2010 to January 2012, 1,082 accidents and failures took place at the substations. Of these 1,082 incidents, 100 of them affected the train operation. 60 trains were cancelled and 177 trains were delayed. Given that over 1,000

accidents or failures occurred over a period of about one year, one might guess that the maintenance works have not been properly done.

In terms of wayside facilities, theft of overhead contact line is rampant. Cable theft from train control facilities and civil engineering structures has been on the rise since 2008. Theft of copper cables by crime organizations is increasingly becoming an international problem. The technologies to replace copper are being developed. However, since the value of copper does not change even with contaminants, there is no real solution to theft. TFR is interested in obtaining information on Japanese technology that can replace the base material copper with other materials.

(2) Challenges

1) Aging of Facilities

Although detailed inspection and maintenance manuals have been prepared for the inspection and maintenance of facilities, some of them do not indicate the inspection cycle. The life cycles (25 years, 50 years) of various main facilities have been designated and simple maintenance and inspection has been carried out. However, even the life cycles of the facilities have shown that the facilities are old, which is a big problem for the future.

2) Stagnation of Technical Level

At the early stage of electrification around 1970, due to the high demand, major European manufacturers established production systems in South Africa. It is believed that South Africa had achieved a relatively high level of technology at the time. However, due to the designation of life cycles of the various major facilities and stagnant investment, investment in facilities and the passing on of technologies have been put on the back-burner, making it an urgent task to improve the level of technical personnel.

3) Restoration from Failures

Thefts of copper products, such as overhead contact lines, from wayside facilities occur frequently. It is necessary to find ways to shorten the restoration time after the occurrence of such incidents.

(3) Capacity of Electricity Companies

Eskom is a major electricity company in South Africa. It has licenses for the generation, transmission, and distribution of electricity. Its generation department generates 85%, its transmission department transmits 100%, and its distribution department distributes 65% of electricity nationwide. In 2011, its maximum supply was approximately 42,000 MW, the maximum load demand was approximately 37,000 MW, and its average supply-and-demand factor was about 85%. The relationship between demand and supply in the last ten years shows that while the supply was increasing gradually from 37,000 MW to 42,000 MW, the maximum load demand is showing a rising trend, despite certain fluctuations. The average supply-and-demand factor trends slightly lower from about 90%, showing conscious effort to maintain steady supply.

Eskom has 27 electricity generation plants, including 13 coal-based thermal power plants, 4 gas turbine power plants, 6 hydraulic power plants, 2 pumped-up hydroelectric power plants, 1 wind power plant, and 1 nuclear power plant. The coal-based thermal power plants generate 85% and the nuclear power plant generates 5% of the total electricity output. In addition, electricity is also generated using renewable energy sources, such as gas and wind power. The nuclear power plant is the only one of its kind on the African continent.

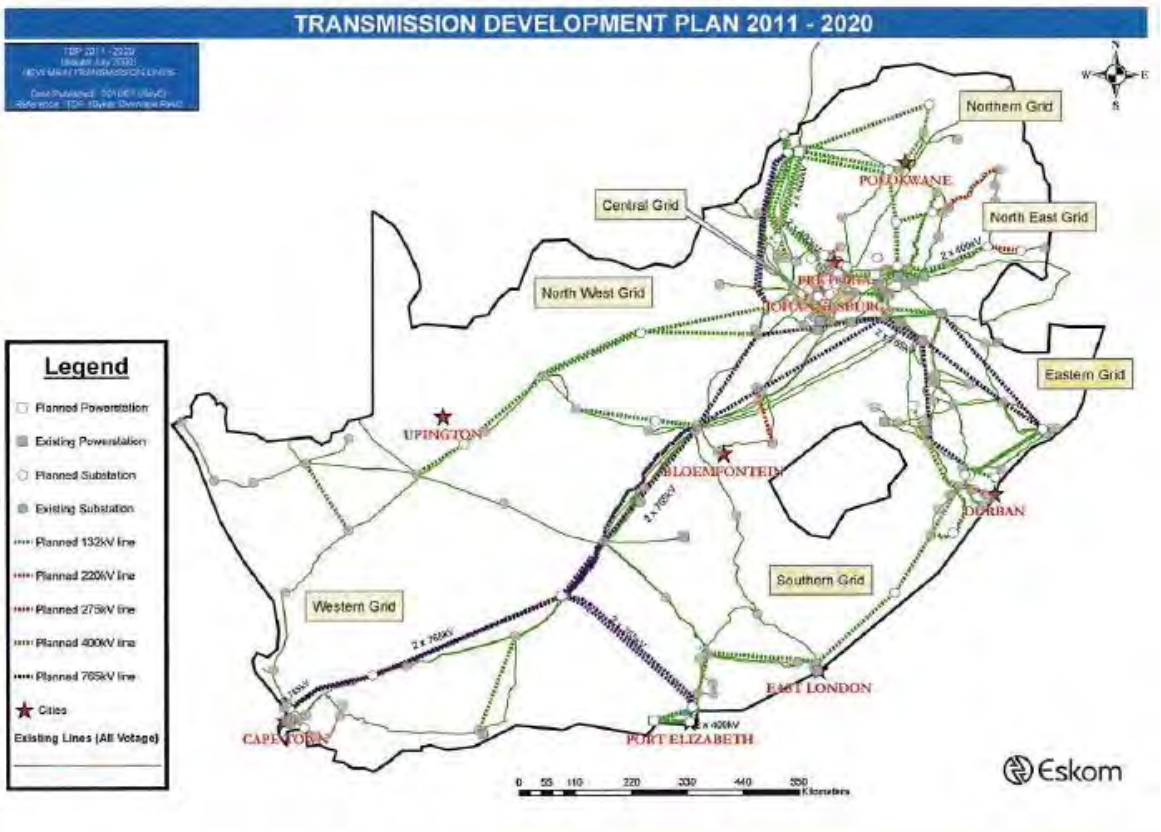
The domestic electricity use is approximately 21,000 GWh annually, an average derived from the three-year data from 2009 to 2011. The railway’s share of Eskom’s load is 2,870 GWh,

approximately 1.4% of the overall usage. Since the percentage is so low, the railway does not pose any problem. However, it is necessary to consider the percentage of electricity use in different parts of the country.

Including modernization of the railway sector such as the TRANSNET 7-year plan, Eskom has forecasted the electricity demand for the next ten years (2011–2020) and drawn up a plan to increase output. Using 2009 or 2010 as the base year, it forecasted that the electricity demand would increase by approximately 15,000 MW in the next ten years. In response to the forecast, Eskom plans to build three thermal power plants, including Medupi, Kusile, and Coal3, to add 20,000 MW by 2020.

Furthermore, it plans to strengthen the transmission system to ensure steady power supply. As shown in Figure 4-14, Eskom plans to add approximately 6,000 km to the 756-kV transmission network, approximately 8,000 km to the 400-kV transmission network, and 740 km to the 275-kV transmission network. In addition, 1,700 km of 800-kV high voltage direct current (HVDC) lines have been planned from the Coal3 power plant in Waterberg to the Gauteng, Kwa Zulu Natal (Central Grid and East Grid) areas.

With the implementation of these plans, the short circuit capacity at the receiving end of each feeding substation relative to the capacity of feeding substations for the railway sector (a maximum of approximately 10 MVA for DC substation and a maximum of 80 MVA for AC substation) is adequate (2000–5000 MVA) even under the current situation. When the electricity system is strengthened with Eskom's 10-year plan, it is believed that the increase in electricity demand from the modernization of the railway sector can fully be met.



Source: "Transmission 10-year Development Plan," Eskom

Figure 4-14 Transmission Development Plan

4.1.4 Civil Engineering and Track

(1) Current State

1) Civil Engineering and Construction Technologies

Until the construction of GAUTRAIN, which opened for service in 2010, there was no construction of new railway lines for about 30 years in South Africa, after the opening of the Iron Ore Line and Coal Line by TRANSNET in 1976. This period, however, was marked by concentrated investment in the construction of roads. Thanks to the economic growth in recent years and hosting of the FIFA World Cup in 2010, many infrastructure facilities have been constructed. Murray & Roberts and other major construction companies took part in many construction projects for highways, soccer stadiums, and others both in South Africa and overseas. Based on this, it is believed that these construction companies have a certain level of construction technology in building bridges, embankment, and tracks.

2) Track Maintenance Technology

a) Track Maintenance Technology of TRANSNET

TRANSNET Freight Rail (TFR) is maintaining the tracks of railway lines owned by TRANSNET.

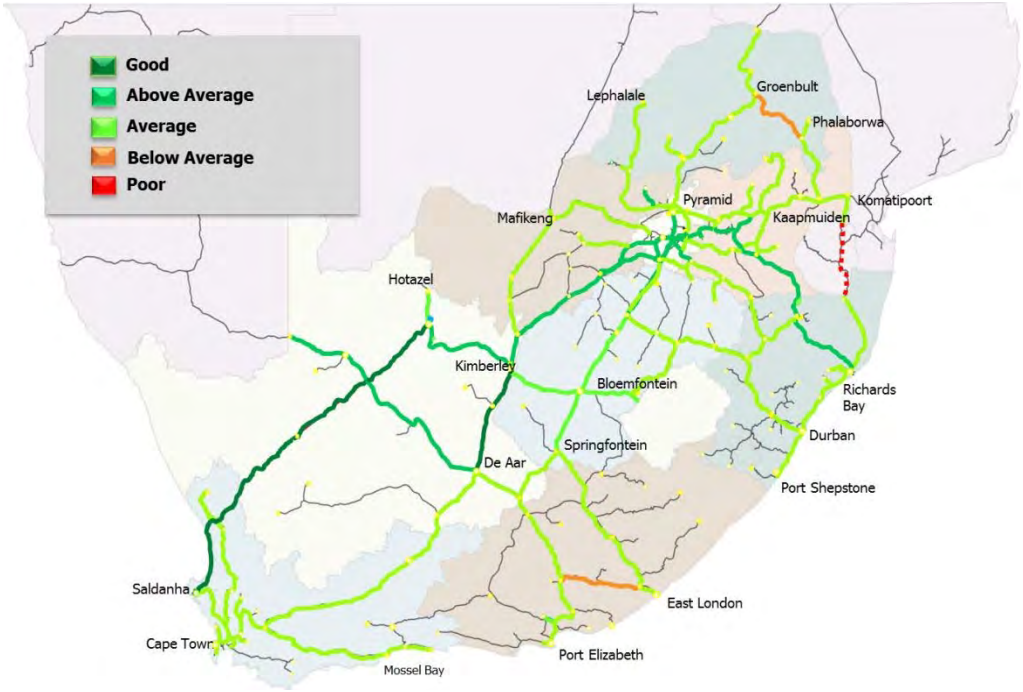
Train operation on the important lines, including the Iron Ore Line and Coal Line, is suspended for ten days every year to perform intensive track maintenance. Besides that, no track maintenance is carried out on a daily basis. At the Iron Ore Line, approximately 60 km of the ballasts are replaced and cleaned every year. It will take twelve years to replace all the ballasts on the line (861 km).

In FY 2009, TFR replaced 471 km of rails and 190 km of sleepers (280,000 sleepers), ballasts, and switches. In FY 2010, it replaced 555 km of rails and 292 km of sleepers, and carried out maintenance on 528 km of tracks. In FY 2011, it replaced 731 km of rails, maintained 690 km of tracks, and replaced 391,000 of sleepers. The last three years show a rising trend in the track maintenance volume.

Of all the track maintenance works, TFR only performed about 20% of them in-house. The other 80% are performed by outside track maintenance companies. In particular, track maintenance works that require the use of large machinery are mostly performed by outside track maintenance companies. Thus, it is hard to say that TFR has sufficient track maintenance technology.

Figure 4-15 shows the track condition of TRANSNET lines in FY 2010. It indicates that lines with high transport demand have above average track maintenance, showing that the tracks have been maintained to a certain extent.

However, it is likely that the tracks have not been adequately maintained. As an example, about 30 incidents of pantograph damage in 19E locomotives that operate on the Coal Line occur every year. The pantograph is damaged after being caught by the overhead contact line. Such damage is caused by the vibration of the train car and when the relative positions of the overhead contact line and the pantograph, pressed by the rail in curved areas, exceed the tolerance. One of the causes is track maintenance. It points to improper management of the positional relationship between the track and overhead contact line.



Source: TRANSNET material

Figure 4-15 Track Condition of TRANSNET Lines (FY 2010)

b) Track Maintenance Technology of PRASA

Table 4-10 shows the PRASA maintenance departments for infrastructure facilities. They are divided into four departments under PRASA Technical. Each department maintains the track facilities, signaling facilities, and electric facilities. They have 374 employees. Among them, 118 are responsible for track maintenance.

Table 4-10 PRASA Maintenance Departments for Infrastructure Facilities

Department		Route	Route length (km)
Gauteng	South	Johannesburg, Pretoria	776
	North	East London, Port Elizabeth	291
Cape		Cape Town	460
Durban		Durban	294

Source: Compiled by Study Team

Track maintenance of the PRASA Metrorail lines are carried out in accordance with the track maintenance plan drawn up every year. The PRASA employees perform regular inspection and other maintenance works. However, maintenance works that require large machinery are performed by outside track maintenance companies, as in the case of TFR. Table 4-11 shows the cycles of track maintenance and inspection.

Table 4-11 Cycles of Track Maintenance and Inspection

Work Task	Work Frequency
1) Operational State Assessment	
Infrastructure Measuring Vehicle	4 monthly
2) Physical State Assessment	
Running lines : Track	48 monthly
Running lines : Turnouts	12 monthly
Yard track	48 monthly

Yard turnouts	24 monthly
3) Safety Inspections Foot Patrolling	
Running lines : Track	2 daily or weekly
Running lines : Turnouts	Monthly
Yard track	Monthly
Yard Turnouts	6 monthly
4) Trolley Inspections	
Track inspector's trolley	Half monthly
Regional engineer's trolley	2 monthly

Source: Compiled by Study Team

As far as the study team could see during our local survey at Metrorail sites, it is difficult to say that track maintenance has been carried out satisfactorily. Garbage was scattered on platform tracks and there were damages on the rails and sleepers. Furthermore, as shown in Table 3-9 in Chapter 3, the national average of mean time between failures (MTBF) of Metrorail tracks in the period between April and August 2012 is 29.6 hours per incident. The MTBF is 9.1 hours in the Metrorail line sections in the Gauteng area (including Johannesburg, Pretoria, East London, and Port Elizabeth), 101.9 hours in the Metrorail line sections in the Durban area, and 27.6 hours in the Metrorail line sections in the Cape Town area. With such frequent occurrences of failures, it cannot be said that the tracks are sufficiently maintained.

Table 4-12 shows the amounts that PRASA invested in the track maintenance of Metrorail lines in the past four years. After 2009, the amounts of PRASA investment have increased and it is conceivable that funds have been appropriated for track maintenance. However, the investment amounts before 2000 were extremely small. It is believed that almost no track maintenance was carried out.

Table 4-12 Investment Amounts for the Maintenance of Metrorail Tracks

FY	2009	2010	2011	2012 (budget)
Track maintenance cost (ZAR)	211 million	172 million	205 million	215 million

Source: Compiled by Study Team

3) Technologies for the Manufacture of Track Materials and Maintenance Equipment

Materials used during track construction and maintenance include rail, fastening device, turnout, ballastless track, ballast, sleeper, and track maintenance equipment. The manufacturing technologies of South Africa for each material are explained below.

a) Rail

Since South Africa cannot produce rail domestically, it imports all of them from overseas, mainly from VEA (Australia), TATA Steel (India), and Germany. The imported rails are welded together in South Africa but the rail welding technology level is extremely low.

b) Fastening Device

All fastening devices are manufactured in South Africa and 98% of them are manufactured by Pandrol SA. The fastening devices used by TRANSNET and PRASA include E-Clip, fist, and bolt fixed fastening device. The spring-type fastening device, known as E-Clip, is mainly used. GAUTRAIN uses fast clip. The steel and plastic materials used for the fastening device are procured domestically.

The fastening devices made by Pandrol SA are manufactured in accordance with the standards of the British Standard Institute (BSI). It is believed that they do not have any technical problems.

c) Turnout

Voestalpine VEA SA manufactures turnouts for ballasted and ballastless tracks in South Africa. It procures materials, such as sleepers and fastening devices, domestically but imports rails from the VEA headquarters (Australia).

d) Ballastless Track

Tubular Track in South Africa is manufacturing ballastless track (T-Track). The rigidly connected structure is made of reinforced concrete vertical beam and steel gauge bar that connects the beams on the left and right. Among the materials that it uses, it imports the rails and track pads. A standard-gauge (1435 mm) T-Track structure allows operation with 36 tons of axle load at 80 km/h. Tubular Track has received technical certification from TRANSNET.

e) Ballast

The ballast is all produced domestically by construction companies in South Africa. No particular technical issues have been reported so South Africa should have sufficient production capability.

f) Concrete Sleeper

All sleepers are produced in South Africa. They are made by concrete sleeper manufacturers or construction companies.

The concrete used to make concrete sleepers is procured domestically. However, it has quality problem. Since the fixing power between the base plate, which is used to stabilize the fastening device to the sleeper, and the concrete is weak, the base plate is made bigger in order to attach it to the concrete. For this reason, the cost of base plate has become higher. Furthermore, the concrete sleepers used in the past for the Iron Ore Line have alkali-aggregate reaction (AAR), which leads to damage in some concrete. This is due to the lack of knowledge on concrete manufacturing when the Iron Ore Line was constructed (1970s).

The pre-stressed concrete (PC) steel rod used in the PC sleepers are imported. They still cannot be manufactured in South Africa.

Based on the above, it cannot be said that the production technologies are sufficient.

g) Track Maintenance Machine

Two companies in South Africa, namely, Lennings and Plasserail, manufacture track maintenance equipment. Plasserail imports the main components of track maintenance equipment from the group companies' headquarters Plasser & Theurer (Australia). Approximately 60% of the components are imported from Australia and approximately 40% are procured locally.

On the other hand, Lennings imports approximately 50% of its components and procures approximately 50% locally.

(2) Challenges

In the TRANSNET 7-year investment plan, as shown in Figure 3-14 in Chapter 3, TRANSNET plans to invest 71.1 billion ZAR in tracks, which break down to an investment of approximately 10 billion ZAR a year on the average. This amount is approximately three times the 3.615 billion ZAR invested in infrastructure in FY 2009. The PRASA modernization project also plans to invest 15 billion ZAR in the next three years. The amount that will be invested in track maintenance is not clear; however, investment greater than the amounts in the past is anticipated. To cope with such modernization, both TRANSNET and PRASA need to enhance technological capability and train technical personnel.

4.2 Brief Review of Applicable Standards

4.2.1 Overview

The Railway Safety Regulator (RSR) formulates the South African Standards on Railway Safety. RSR is an organization established in 2004 under DOT pursuant to the National Railway Safety Regulator Act. It supervises the operation and management of railways, as well as (1) issues Safety Permits to railway operators, (2) formulates the Railway Safety and Technical Standards in accordance with the laws, and (3) provides guidance for improving the operation of railway operators.

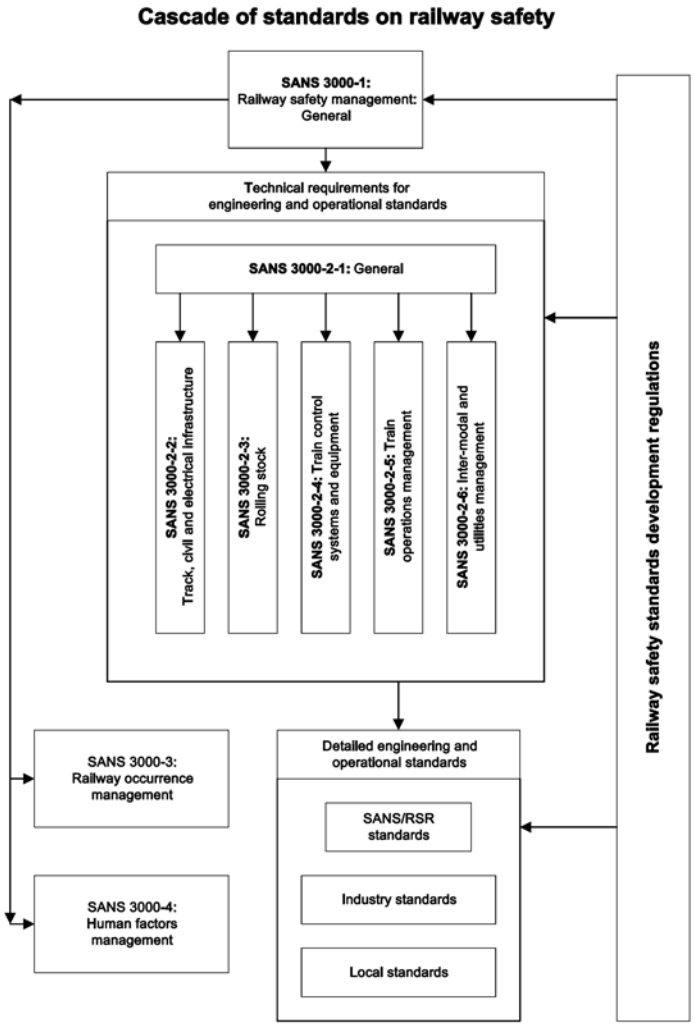
The Standards on Railway Safety is part of the South Africa National Standards (SANS). As shown in Table 4-13, the Standards are numbered, organized, and formulated in series. The completed standards are issued by the South African Bureau of Standards (SABS).

Table 4-13 Railway Safety Standards Issued by SABS

Code	Contents	Issued
SANS 3000-1	General	October 2009
SANS 3000-2-1	Track, civil and electrical infrastructure	April 2008
SANS 3000-2-2	Track, civil and electrical infrastructure	May 2008
SANS 3000-2-2-1	Track, civil and electrical infrastructure	April 2012
SANS 3000-2-3	Rolling stock	May 2008
SANS 3000-2-4	Train authorization and control systems and equipment	In preparation
SANS 3000-2-5	Train operation management	In preparation
SANS 3000-2-6	Interoperability, intermodal and utilities management	In preparation
SANS 3000-3	Railway occurrence management	In preparation
SANS 3000-4	Human factors management	February 2011
SANS 3000-5	Railway stations	In preparation

Source: Compiled by Study Team

Figure 4-16 shows the specific system of Railway Safety Standards



Source: "SANS 3000-2-1:2008 Railway Safety Management"

Figure 4-16 System of Railway Safety Standards

Even now, RSR is in the process of formulating the Standards on Railway Safety. The ones that have been completed and approved are enacted in sequential order. The opinions of the railway operators are heeded during formulation of the Standards.

The enacted Standards do not give specific values. They put forth the requirements that must be met, which are mainly the so-called performance criteria. Each railway operator then established its specific standards for the requirements stipulated in the above-mentioned Standards.

In addition to the standards of the Rail Safety and Standards Board (RSSB) of the United Kingdom, the former colonial power, the technical standards of representative railway operators TRF and PRASA also incorporate the standards of the countries in which the rolling stock is manufactured, such as the Association of American Railroads (AAR, USA) and the International Union of Railways (UIC).

4.2.2 Rolling Stock

(1) Axle Load

To enable mass transportation, South Africa uses long freight trains with extremely high axle load, at a maximum of 30 tons in the case of the Iron Ore Line, for train operation. In many

other line sections as well, the maximum axle load is 20–26 tons. The freight cars that carry the freight and the locomotives hauling them are designed with maximum axle loads that are permissible for the line sections where they operate to ensure sufficient tractive force. It is not rare to have maximum axle load of 26 tons in various European countries. Since the conventional lines in Japan are limited to a maximum axle load of 16 tons, Japan does not have any rolling stock with such high axle load. When the axle load is high, it is certainly necessary to pay attention to the strength. Japan does not have any experience or accumulated data on how the 25–30 ton axle load will change the adhesion coefficient, which indicates the ease of sliding between the rail and the wheel. South Africa requires an adhesion coefficient of 40%. Japan does not have any example of such high adhesion coefficient. However, the Japanese manufacturers are accumulating experience through the manufacture of the Series 15E electric locomotives (axle load 30 tons) for the Iron Ore Line. At this point, the Study Team does not anticipate any problems.

(2) Car Body Strength

The Japanese technical standard stipulates that the car body structure be "solid, strong, and can endure the train operation," The standard's interpretative criterion clearly states that the strength of the car body is premised on normal operation. It does not require the strength to endure the head-on collision of trains or the impact of fallen rocks. In this respect, the South African standard mandates strength to endure collision. This stems from a philosophical difference between using a signal security system or grade crossing security system to prevent collision and ensuring collision safety of the car body on the assumption that collision will happen.

The South African standard stipulates a compressive load of approximately 300 tons for locomotives. It is even higher than that of UIC. It is because the long freight trains being used exert heavy load when navigating gradients and braking. Even so, Japanese manufacturers can still adequately fulfill the requirement as they have delivered rolling stock to South Africa in the past. Increasing the strength of the car body also increases its weight, making it difficult to design a car body within the permissible range of axle load. However, South Africa already has higher permissible axle load compared to Japan, increasing the weight of the train car is not a problem.

(3) Gauge

South Africa uses the 1065-mm gauge, which is virtually the same as the 1067-mm gauge used in Japan. This seems to put the Japanese manufacturers in favorable light but in reality, gauge is not an issue for the manufacturers.

(4) Electric Equipment

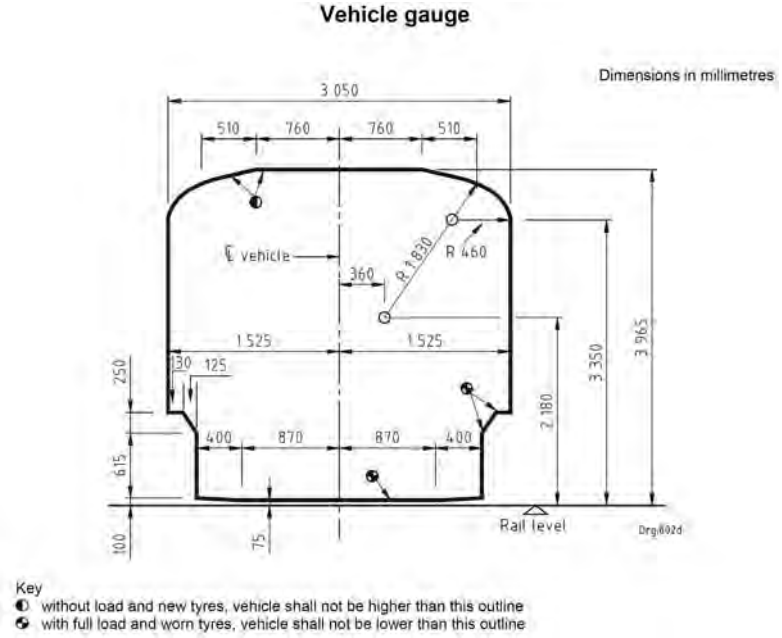
The electrical equipment in South Africa's rolling stock follows the International Electrotechnical Commission (IEC) standards, which started by citing the British Standard (BS). Since the Japanese manufacturers have participated in many international projects, they have dealt with many international standards. In recent years, the push to equalize the International Organization for Standardization (ISO), European Norm (EN), and International Electrotechnical Commission (IEC) into common standards has made progress, further removing the barriers.

(5) Electrification System

The Iron Ore Line uses the 50kV AC electrification system, an application of the highest voltage in the world. It is important to secure an insulation distance between the pantograph areas and the transistors. Other than that, the structure is not different from other rolling stock.

(6) Vehicle Gauge

The vehicle gauge showing the maximum permissible cross-section of the vehicle, as shown in Figure 4-17, is not substantially different from that of Japan.



Source: "Clearances on ballasted track (1065mm track gauge)," RSR, 2009

Figure 4-17 Example of Vehicle Gauge in South Africa
(in the case of 1065-mm gauge and ballast track)

Historically, the Japanese rolling stock manufacturers have dealt with the different technical standards of foreign countries and have exported many trains. They also have experience dealing with the heavy freight trains unique to South Africa. No technical issue about rolling stock is likely to obstruct the participation of Japanese manufacturers.

4.2.3 Signal

The "SANS3000 Part 2-4: Technical requirements for engineering and operational standards – Train authorization and control systems and equipment," which is equivalent to the technical standard on the safety of signaling facilities in South Africa, is currently being formulated. It has not gone into effect. The following are the differences from the Japanese standard, summarized based on the technical specifications submitted for bidding.

These differences are caused by different operating conditions and environmental conditions in South Africa. They are not technical issues that the Japanese companies cannot resolve if they were to participate in South Africa's projects.

- Since some of the freight yards have both 3kV DC and 25kV AC sections, when the train moves between the two sections, the DC–AC switchover combines the signals' interlocking conditions and operates automatically.
- South Africa uses a block system that has both block sections and overlap sections. The length of an overlap section is over 275 m for the freight trains and over 110 m for the passenger trains. In sections where it is not possible to secure enough braking distance, an overlap section or a safety siding is installed.
- The track circuit in South Africa has a train shunting sensitivity of 0.5Ω and leakage resistance of over 2Ω/km. Compared to Japan, South Africa has higher axle load (maximum

30 tons) and longer trains (maximum 4 km). It has little rain and is relatively dry.
(Reference: In Japan, the shunting sensitivity is 0.06Ω and the leakage resistance is 2Ω/km.)

- The Iron Ore Line in South Africa uses the 3-aspect signals (G, Y and R). A white aspect (W) is added to the mainline branch line and the sideline branch line to notify the driver in advance with a G-W or Y-W aspect.

4.2.4 Electric Supply

The railway electric equipment in South Africa follows the IEC and EN standards. EN is a common standard for all European countries. Many of its standards are from the British Standard. The IEC tends to follow the EN. Since the IEC is somewhat different from the Japanese Industrial Standards (JIS), it presents certain challenges for Japan but they can be overcome.

(1) Difference in Voltage

The DC electrified sections in South Africa use the international standard voltage of 3kV while Japan uses the standard voltage of 1.5kV. Given that the power consumption of the traction load is the same, when the voltage is doubled, the electric current is halved and the voltage drop ratio becomes one-fourth. Therefore, in the case of 3kV feeding, it is possible to have longer interval between substations, making 3kV feeding a more advantageous method than the 1.5kV Japanese feeding standard. Furthermore, since the traction load current is smaller than the 1.5kV feeding, it will have a bigger difference from the traction load current when a ground fault or a short circuit occurs along the railway line, making it easier to protect the feeding system of the railway line than in Japan. Since Japan has not made much progress in the 3kV feeding technology, it will be difficult to make inroads in this area. However, technology to identify failures from the sizes of the fault current and operation current will be effective in shortening the restoration time.

(2) Difference in Transformers for AC feeding

South Africa's AC substations mainly use the 88kV and 132kV receiving voltages. A substation typically uses a single-phase transformer to receive current from a 3-phase electricity source. Due to concerns about the voltage unbalance ratio, Japan uses complicated transformers with interconnection, including the Scott connected transformer, modified wood-bridge connected transformer, and roof delta connected transformer, etc. The reason is to reduce the unbalance or voltage fluctuation of a particular phase of the voltage source when a large volume of single-phase current from a 3-phase electricity system is used. When comparing the electric power systems of South Africa and Japan in the same voltage class, the South African system has high short circuit capacity, strong electric power system, and its railway load capacity is lower than that of Japan. Because of these reasons, South Africa can make do with a simple structure, such as the V-connected two single-phase transformers. It may be difficult for Japan to make entry.

(3) Difference in Earth Connection of AC Feeding Methods

The rails are grounded in the AC electrified sections in South Africa. In Japan, however, the rail uses ungrounded AT feeding system in the AC electrified sections to prevent electromagnetic interference for telecommunication. The rail is bonded to wayside structures along the line in some sections to control the potential. Due to the difference in environmental conditions near the railway and the difference in thinking about maintenance interval, IEC and JIS have different limit values for touch potential. However, adaptation is possible.

4.2.5 Civil Engineering

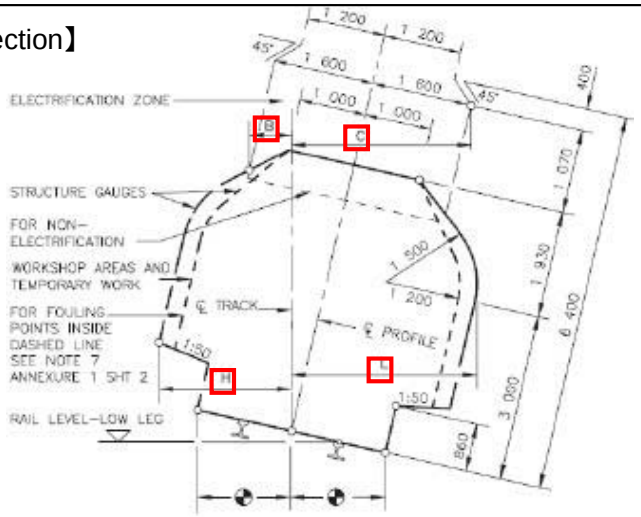
(1) Axle Load

The maximum axle load of the TRANSNET lines is 30 tons and the maximum axle load of the PRASA lines is 20 tons. Both are higher than the axle load in Japan (maximum axle load of the conventional line is 16 tons). On the other hand, Japan has already manufactured and exported rails that are designed for high axle load. The high axle load can be accommodated by increasing the size of the structure.

(2) Construction Gauge

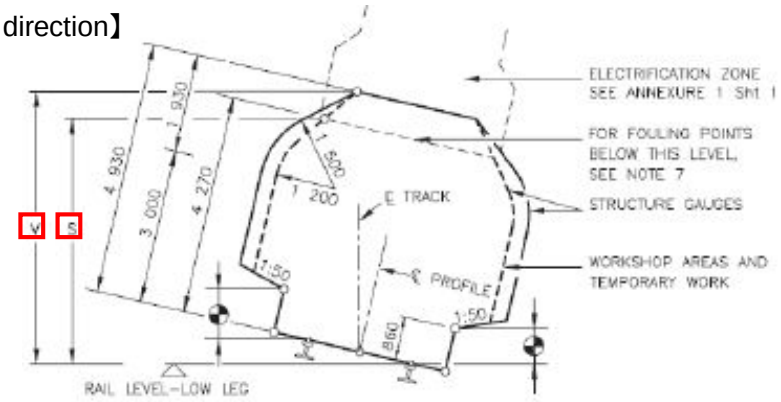
Figure 4-18 shows the construction gauge in the horizontal and vertical directions. Different from the Japanese standard (400 mm in Japan), the construction gauge in South Africa has a 925-mm leeway in the horizontal direction from the vehicle gauge. However, the difference will not act against the introduction of Japanese technologies. It is possible to construct structures that comply with the construction gauge of South Africa.

【Horizontal direction】



Curve radius (m)	Cant		No cant	cant	
	H(mm)	L(mm)	H、L	B(mm)	C(mm)
100	2700	3030	2750	1140	2050
300	2540	2760	2560	1250	1900
500	2510	2680	2520	1320	1850
1000	2480	2600	2490	1380	1760
3000	2470	2470	2470	1500	1600
>5000	2460	2460	2460	1600	1600

【Vertical direction】



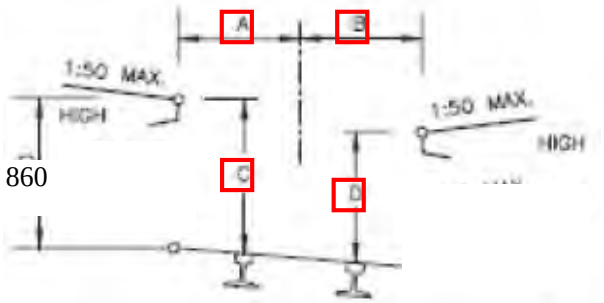
Curve radius (m)	Non-electrified section	Electrified section	
		3kV, 25kV	50kV
	S(mm)	V(mm)	V(mm)
100	4470	5050	5400
300	4410	5020	5370
600	4370	5000	5350
1000	4350	4990	5340
>3000	4270	4930	5280

Source: PRASA material

Figure 4-18　Construction Gauge in Horizontal and Vertical Directions

(3) Platform Limit

Figure 4-19 shows the platform limit at a PRASA station. There are certain differences when compared to the Japanese standards, however, it is possible to comply with South Africa' platform limit when constructing the structure.



Curve radius (m)	A(mm)	B(mm)	C(mm)	D(mm)
100	1650	1790	890	810
200	1530	1630	890	820
300	1520	1580	890	830
400	1520	1550	880	840
500	1520	1540	880	850
1200	1520	1520	860	860
2000	1520	1520	860	860
3000	1520	1520	860	860
Straight line	1520	1520	860	860

Source: PRASA material

Figure 4-19 Platform Limit

4.3 Current State and Challenges of Related Private Sectors and Supporting Industries

4.3.1 Rolling Stock

(1) Current State

1) Manufacture of Rolling Stock

South Africa had been manufacturing new rolling stock domestically since the old days. The level of technology was high. The Series 6E electric locomotive made by UCW recorded a maximum speed of 245 km/h in a speed test conducted in 1978. It is still the world record for narrow-gauge railway today. However, amid the social changes that took place since the second half of the 1980s, investment in railways was suppressed. For about two decades, the rolling stock manufacturing field was in distress.

From the second half of the 2000s, however, the manufacture of freight locomotives was restarted and it continues today.

At present, there are two major rolling stock manufacturers: Union Carriage and Wagon (UCW) and TRE. They account for almost all of the South African market. Currently, they manufacture locomotives and freight cars. No electric trains (EMUs) have been produced since delivery of all of Gautrain's cars (81 cars produced in South Africa).

a) UCW

UCW has been cooperating with Mitsui and Toshiba in delivering Series 19E electric locomotives for the Coal Line and Series 15E electric locomotives for the Iron Ore Line to TFR since 2008. The Japanese companies are responsible for the electric equipment and systems for the locomotives. At the beginning of production, since many engineers and designers from the past had already left UCW, Toshiba sent about 20 engineers to station in South Africa to reestablish production control, provide technical supervision at production sites, and offer quality control guidance to suppliers. The production will reach 110 units of Series 19E and 44 units of Series 15E by 2013, plus an additional order for 32 units of Series 15E. Both series use the AC traction motor (3-phase AC induction motor), which is the standard for today's railcars. However, since the electronic components (elements) and circuit board are not produced in South Africa, the overall local procurement rate is 48%. The local procurement rate for machinery part (by UCW) is 80%. For Series 15E, its overall local procurement rate is 50% and local procurement rate for machinery part is 85%.

The initial 15 units of the Gautrain trains, which opened for services in 2010, were manufactured by Bombardier Inc. at its Derby factory in the United Kingdom and imported into South Africa. The materials and component parts of the other units were supplied to UCW, where they were assembled.

b) TRE

TRE has been cooperating with GE since 2011 to manufacture Series 43 electric diesel locomotives for general freight use at the Koedoespoort factory (Pretoria). One hundred units are scheduled to be delivered by 2013, with an additional order for 43 units.

The freight cars are manufactured at various workshops in Germiston, Uitenhage, and Bloemfontein. By March 2013, the Durban and Cape Town workshops are expected to start manufacturing container freight cars.

Although no passenger trains are manufactured in South Africa at this time, TRE will surely expand into this area, in order to meet the procurement need of PRASA for electric commuter trains, comply with the BEE Act, and utilize the production capability in South Africa.

c) Grindrod

This company is a unique existence in that it does not have TRANSNET and PRASA as its main customers. It is originally a maritime shipping company. After mine management, it entered the diesel locomotive business since 2009. It is currently producing diesel locomotives for dedicated lines used by mining companies and exports to countries in southern Africa and Australia. It also does not compete with the two major manufacturers, UCW and TRE, in terms of customers or products.

At present, it produces 10 units of diesel locomotives for mainline use annually. Its target is to increase production to 50 units per year.

It produces diesel engines, the main component, in South Africa in cooperation with EMD, a US company. The traction motor and control system are supplied by National Rail Equipment Company (NREC), a US company. The company specializes in locomotives for export. One of the reasons is that it is too costly for it to meet the necessary local production requirements for domestic sale.

d) Rolling Stock Repair Companies

Besides the three companies mentioned above, there are also companies contracted by the various railway operators to repair or refurbish their existing rolling stock. The main companies are Commuter Transport Engineering (CTE), WICTRA, and Naledi Rail Engineering. Together with TRE and UCW, the five companies each have 20% share of the refurbish market of the

PRASA commuter trains.

They repair the whole car, from the car body to the running gear. As they expand their car category to include locomotive in the future, they will certainly go into production, given the BEE Act, by collaborating with foreign companies to meet the procurement need of PRASA for commuter trains.

2) Car Components and Parts

There are many companies in the field of car components and parts, and their levels vary.

Timken South Africa (bearing), Knorr Bremse South Africa (brake system), LH Marthnusen (coil/ rectifier), Mersen South Africa (carbon brush), and ABB (motor) have strong connections overseas. They all have foreign parent companies. These companies often implement quality control as a group or have group supply chains with a global scale. It is believed that most of them can maintain product quality at a certain level.

Although the main control circuit of today's railway car has all been computerized, South Africa does not produce electronic parts or circuit boards domestically. It must rely on foreign companies. There will certainly be strong push to increase local production rate in this area in the future. At this time, TFR has imposed stringent conditions in its procurement of locomotives for general freight use. It requires raising the local production rate to 65% for locomotives in general and 80% for electric components and parts after three years upon receipt of the order.

On the other hand, Ratocon Engineering (gear case), OTD (pantograph), Booyco Engineering (air-conditioning for train cars), and Siyahamba Engineering (door for train cars) are local companies specializing in components and parts, especially machined parts. Many of them do not have large production scales because of the limited railway investment in the past 20–30 years. There is also considerable difference in the quality, safety management, and education and training of the employees, depending on the approach and motivation of the management. For example, in 2006 when Mitsui and Toshiba received the order for electric locomotives for TFR use, Toshiba had to provide guidance to Rotacon Engineering repeatedly before it could achieve the quality level required for the finished products. In this backdrop, it is necessary to review the quality of the actual products carefully in South Africa.

(2) Challenges

1) Education and Training to Enhance Technical Capabilities

At the rolling stock manufacturing sites, the numbers of engineers and skilled workers from the past are dwindling as they are approaching retirement. Succession of their technical expertise has become a problem. During the period when investment in railway was suppressed, many of the mid-level employees, who would have become the next generation of engineers, resigned en masse. Today it is very difficult to find successors. Furthermore, the skills of the newly hired and young workers, who would have been trained by those mid-level employees, have not had much improvement. New employees cannot grow into new mid-level employees in this vicious cycle. To break the cycle, it is necessary to provide assistance to enhance the technical skills of employees at all levels simultaneously.

There are many small and medium-sized companies in the car parts industry. Similar to other industries, they are struggling to secure high-quality workforce. Very often, they cannot provide other education and training besides on-the-job training. (Employees have no choice but to learn while doing the actual work.)

It is certain that future procurements will require a higher level of localization. Collaborating with these companies will be a prerequisite for Japanese companies to make inroads into the South African market. Therefore, how to assist these companies in education and training will be an important factor in ensuring steady supply of high-quality rolling stock. It will be the key

to entering the South African market.

2) Securing Works

It is necessary to secure a certain level of works on a continuous basis in order to maintain technical capabilities. As an example, TFR is currently planning to procure locomotives for general freight business. Within the short period of six years, 1,064 locomotives will be manufactured. However, it is not clear at this time what the plan is going forward. The same is true with regard to the procurement of PRASA commuter trains. Over a period of twenty years, 360 train cars will be produced annually. There is no indication as to what direction the rolling stock industry shall take after their production is finished. Once the orders stop, it will be difficult to maintain or pass on the technical expertise without actual works. There is a high chance that those hard-earned skills will be lost again.

3) Local Production of Components and Parts

It is a big challenge to increase the rate of local contents when electronic components and parts are not manufactured in South Africa. At this time, it is not clear if it is acceptable to purchase elements produced in other countries and assemble them in South Africa, or if the elements have to be manufactured in South Africa to be considered locally produced. Depending on the answer, Japanese companies will need to adopt a completely different approach.

4.3.2 Signal

(1) Current State

1) Status by Industry

To understand the current state and issues of the railway signal industry in South Africa, the Study Team selected 10 local companies to find out which of the four industries, namely, manufacturing, installation/construction, engineering, and maintenance that they belong. Table 4-14 shows the results.

Table 4-14 Signal-related Companies by Job Function

Name of company	Manufacturing	Construction	Engineering	Maintenance works
Siemens	○	○		
Bombardier	○	○		
Alstom	○	○		
Thales	○	○		
Actom	○	○	○	○
Mehleketo	○	○	○	○
Hatch			○	
Arcus GIBB			○	
Mott Macdonald			○	
Lebone			○	

(Notes)
Manufacturing: Local production or assembly of imported goods
Installation/Construction: Installation of facilities, construction, testing
Engineering: Planning, design, construction management, maintenance management, etc.
Maintenance: Maintenance works, accidents restoration and support, hazard response and assistance
Source: Compiled by Study Team

The signal industry in South Africa does not have a system that clearly divides companies into four functions. In general, they are divided into manufacturing/construction and consulting.

A local company Mehleketo is a unique example. Although its main business is consulting, it manufactures and installs signaling equipment not intended for foreign manufacturing companies. It also provides maintenance and hazard restoration assistance. Actom is a local manufacturing company. It not only installs, constructs, and tests the equipment that it manufactures and assembles but also actively participates in consulting business.

As shown by these examples, the companies in these four industries are securing personnel who can perform different functions in order to stabilize business operation. This is probably due to changes in the volume of customers' orders and seasonal fluctuation.

Regarding the large projects being planned by the railway operators, it is true that local companies are wary about the risk of a drop in demand after they have finished the production of one big order.

2) Status of Localization in Manufacturing Industry

The Study Team classified the signaling facilities in South Africa into field equipment and CTC equipment/ system equipment, such as interlocking device, to find out the status of localization by domestic and foreign manufacturers. Table 4-15 is a summary of the survey results.

Table 4-15 Localization of Signaling Equipment and Devices

	Equipment/device		Localization	Future trend
System	Interlocking device	Electronic type	Import and assembly (Siemens/Bombardier)	Localization of software data
		Hybrid type	Rely on import (Siemens/GEC/Alstom)	Plan to upgrade to electronic type
	Centralized train control (CTC)		Import and assembly	
	Automatic train protection system (ATP)		No	Plan to introduce system (rely on import)
Field equipment	Signaling equipment	Conventional type	Yes (Actom / Mehleketo)	
		LED type	Localization is planned (Actom)	
	Track circuit	Insulated	Yes (some materials rely on import)	
		Non-insulated	Rely on import (ERBTechnology)	
	Axle counter	Thales	Rely on import (Actom)	Possibility of localization if demand increases
		Siemens	Rely on import	
	Switch		Yes (Actom has 95% share in South Africa)	
	Level crossing equipment		Yes	
	Cable		Yes	
	Box and housing		Yes	
	Freight train monitoring system		Yes (Ansys / Inteletrack)	

Source: Compiled by Study Team

a) Field Equipment

Major local signal manufacturer, such as Actom and Mehleketo, are producing almost all the field equipment (signaling equipment, switch, level crossing equipment, box and housing, etc.) locally. In particular, Actom, which has technical collaboration with Alstom, is already producing high-quality switches locally and has 95% of the market share in South Africa.

Even among the field equipment, approaches to the localization of track circuit and axle counter, which are both train detection equipment, are different.

First, the track circuit is divided into the insulated type (Jeumont type) and non-insulated type. Except for the specially imported parts (special condenser and track relay), most of the equipment of the insulated type is manufactured and assembled locally using domestic parts. Since the domestic and overseas demand for these special parts is low, fulfilling the safety requirements will make the production very costly. Therefore, these parts are imported. The non-insulated type must rely entirely on import due to technical and cost reasons.

On the other hand, since the scale of the axle counter market until now has been small and the cost is high, Thales and Alstom have avoided localization. In reality, even though Actom is in a collaborative relationship with Alstom, it has not succeeded in mastering the technologies transferred. Instead, it is content with the status as the only sales agent of axle counters manufactured by Thales.

However, railway operators (TRANSNET and PRASA) have indicated a change in policy recently to switch from track circuit to axle counter. This raised the possibility that axle counter will be targeted for local production in the future. It is because axle counter is resistant to lightning damage, which occurs frequently in Gauteng province, and it can be installed at low cost in long sections.

b) System Equipment

South Africa lags behind in the technical level of system equipment, such as electronic interlocking device. At this time, it is using the old hybrid type-interlocking device, which shall be upgraded as soon as possible.

The vital components of the interlocking device are all imported but the non-vital components are mostly produced domestically.

Siemens, Bombardier, and Thales are the major companies delivering interlocking devices to South Africa. Siemens imports both the hardware and software of the device from Germany. Only the peripheral parts for transmission (optical fiber and cable) are manufactured and assembled locally. On the other hand, Bombardier imports both the hardware and software of the device and assembles them locally.

South Africa is debating the pros and cons of whether to produce software locally from the perspectives of the cost of development by local software engineers and the performance of the developed software (cost performance).

In this backdrop, Siemens is taking initiatives to pursue localization. Rather than the software itself, it is limiting localization to the compilation of software control data, which is important for the interlocking device. By doing so, it hopes to improve software quality.

The centralized train control (CTC) system for the new model trains and the automatic train protection (ATP) system, which is expected to be introduced in the future, will probably go through the same process as the interlocking device with regard to localization.

3) Status of Signaling Consulting Industry

The signaling consulting industry in South Africa is facing a very difficult environment. TRANSNET awards most of its contracts to its affiliated consulting company (Transnet Capital

Projects) and very few to outside consulting companies. The mining companies already have contracts with the RCE Consultants. Railway operator PRASA is awarding contracts to private consulting companies, which are locked in fierce competition. The major consulting companies are as follows:

- Arcus Gibb (major company)
- Hatch (major company)
- Actom
- Lebone Engineering
- R&H Railway Consultants
- MottMacDonald
- Siyaya (joint venture agreement with DB International)
- Transnet Capital Projects (former Protecon)
- RCE Consultants

Table 4-16 shows the members of joint venture teams that have been awarded orders from TRANSNET, PRASA, and Gautrain in the past.

Table 4-16 Signal Engineering Group

Group	Leading Company	JV Company	Client
Group A	Mott MacDonald	Lebone	TRANSNET PRASA ESKOM
		Bombela	GAUTRAIN
Group B	Hatch	Actom Mehleketo	PRASA
Group C	Lebone	Bombela	SARCC TRANSNET
Group D	R&H		
Group E	Arcus Gibb	Actom	PRASA
Group F	Aurecon	Ansaldo	
Group G	Actom	Acrus Gibb	PRASA
		Hatch	
		Worley Parsons	

Source: Compiled by Study Team

What the Study Team can discern from Table 4-16 about the major consulting companies in South Africa is that the two local leaders Arcus Gibb and Hatch are collaborating with Actom in different projects while Mott MacDonard and Bombela are collaborating with Lebone Engineering in the Gautrain project, and there is no consultancy specializing in telecommunications.

Transnet Capital Projects is handling the consulting of TRANSNET projects singlehandedly. It plans to maintain and improve technical capabilities by working on development and upgrade plans.

(2) Challenges

1) Strengthening Construction Capability

Actom and Mehleketo are the two major local companies in the industry that construct signaling facilities in South Africa. In the past turnkey construction projects, they have experiences

collaborating with Siemens, Bombardier, and Thales. Although both companies have certain levels of expertise in constructing conventional signaling facilities, skilled engineers are in severe shortage. The two companies combined have only 10 registered certified signal engineers. In the future, the construction companies will be required to establish construction systems to handle the new development projects ordered by railway operators (TRANSNET, PRASA, etc.). Therefore, it is necessary to take measures to improve the technical capabilities of technical personnel in order to master the construction and testing methods of the newly introduced modern facilities and enhance the current construction capabilities.

2) Promoting Local Production

In South Africa's railway signal industry, if a foreign company and a local company form a collaborating group and appropriately share manufacturing and construction in a conventional project, it is relatively easy to achieve the localization rate (50%) required because of the high labor value. It is understood that these companies are experienced with the general issues of localization.

However, the requirements by railway operators in recent bidding have reached higher levels. The Study Team continues to enter a phase in which system equipment, field equipment, and software development requiring advanced technical capabilities, for which localization was not required until now, will be subject to localization requirements. As a condition to pursue localization, it is necessary to not only ensure quality improvement and no cost constraints but also determine whether there will actually be steady and continuous demand in the future.

To tackle the situation, South Africa needs to develop a system to increase the volume of hardware and software, which had relied completely on imports so far, in phases and work towards localization. It is an important task to provide education and training programs domestically and abroad in order to enhance the technical capabilities of personnel and pass on technologies.

As explained above, local companies are pursuing localization at this time within the limited scope of technical transfer from foreign companies. Among the products that are made with advanced and latest technologies, local companies may have difficulty deciding which products are for localization, and how to master the technologies for localization.

In addition, since PRASA recently announced the policy to emphasize maintenance in its bidding requirements, maintenance-related equipment shows potential for localization.

3) Response to Technical Transfer and Skills Training

From the perspective of maintaining and improving the construction capabilities of local companies, since foreign contractors will have to rely on local construction companies to carry out construction works and perform testing, ideas to develop a system that can maintain and enhance such construction capabilities are being sought. A condition of the railway operators is to require foreign contractors to contribute a portion of the contract amount to the technical transfer and skills training of local companies. It will be a challenge to figure out how to provide specific skills training to local companies so that they can acquire the necessary skills for installing new equipment and machinery and conducting tests, in which they have no practical experience.

4.3.3 Electric Power

(1) Current State

Main equipment, such as substation, is procured from the leading foreign companies shown below. Upgrades and replacements are carried out by domestic companies.

1) AC Circuit Breaker
The main equipment of substation facilities are procured from major manufacturers, such as Siemens, ASEA, AEG, Alstom, Delle Alstom, Areva, and so on.

2) Transformer
The under 5MVA transformer used for the rectifier for DC substation are from manufacturers such as ASEA, GEC, AEG, ABB, Powertech, WEG, Hawker Siddeley Africa, etc. The 20MVA class transformers for 25kV AC substation are delivered by NEI Transformer, GEC, ABB, and Powertech as single-phase transformers. The 50kV transformers are supplied and managed by a utility company (Eskom).

3) Rectifier
The rectifiers for DC substation use are procured from manufacturers such as Semikron, AEG, etc.

4) DC High-speed Circuit Breaker
Most of the high-speed circuit breakers for output at DC substations are the open-air type. They are manufactured by Ansaldo/EMC and ABB.

5) Overhead Contact Line and Other Maintenance Parts
The wayside cables are supplied by MTech, the fixing brackets from Quel Engineering and EBM, and the insulators from Speedcrafts, etc. To cooperate in the effort to nurture small and medium-sized businesses (BEE businesses) in South Africa, TRANSNET purchases other maintenance parts from small and medium-sized businesses in South Africa through its material procurement department. Examples are Boipelo Engineering, Active Power Projects, Gakennoshi, Power Projects, Conco, Ampcor, LHM, etc. These small and medium-sized businesses purchase parts and materials from ABB, Alstom, Semikron, and other major manufacturers.

(2) Challenges

Over forty years have passed since the period around 1970 when electrification was promoted. The time has come when aging of the main equipment at substations becomes noticeable. It is believed that the technical level at the time when the substations were constructed was sufficient for local production. Daily inspection and maintenance have been carried out. The life cycles of main equipment have been designated (25 or 50 years) and overhaul is contracted out to major manufacturers. Although the maintenance products are procured from domestic companies, the domestic companies are importing component parts from major manufacturers. Such practice delays the succession of technologies, making it a challenge to improve the technical skills of upgrading facilities, inspection, and maintenance. Upgrade and replacement are carried out by domestic companies. It is advisable for them to improve their technical abilities.

4.3.4 Civil Engineering

(1) Current State

1) Construction Companies
South Africa has large construction companies, such as Murray & Roberts, Grinaker LTA, Group Five, Stock Building, etc. They participate in many construction projects. Besides the domestic construction projects, they also made inroads into other African countries and participate in ODA projects at various places. In recent years, they also took part in railway projects. Murray & Roberts participated in the construction of Gautrain and Grinaker LTA is taking part in the Metrorail extension project (in progress) in the Durban area.

2) Track Maintenance /Construction Companies

The major players in South Africa are the three local companies Lennings, Plasserail, and SIMS. Lening and Plasserail have been maintaining and constructing tracks for over fifty years. They also manufacture track maintenance equipment in-house. SIMS procures track maintenance equipment from Plasserail and DESEC (manufactures track maintenance equipment, Finland). The size of South Africa's track maintenance business is approximately 500 million ZAR annually.

3) Concrete Sleeper

The three major local concrete sleeper manufacturers in South Africa are Infraset, Rail2Rail, and GPT. Among the three, Inftaset has 60% share, Rail2Rail 20–25%, and GPT15–20%. The construction company Grinaker LTA also manufactures concrete sleepers.

The market size of concrete sleepers is approximately 24 million ZAR (60,000 sleepers) per month and approximately 300 million ZAR per year. The market size of track materials, including rails and sleepers, is approximately 1.2 billion ZAR per year.

4) Fastening Device

The major player is Pandrol SA. It has 98% of the market share of fastening device in South Africa. In particular, it has 100% of the market share of E-Clip and Fist, and 95% of the bolt fixation type. Although many companies can manufacture the bolt fixation-type fastening device, all of them are small, resulting in the monopoly of Pandrol SA. In FY 2011, Pandrol SA delivered 3.5 million fastening devices to TRANSNET and PRASA.

Since only one iron and steel company (Arcelor Mittal) supplies the steel for making fastening devices, the quality and price of the steel material can be swayed substantially.

5) Ballastless Track

The only major player is Tubular Track. It developed the ballastless track in 1986–2000. The track was first used at a PRASA Metrorail station. Today eighteen stations are using the Tubular Track. There is a plan to use it in forty more stations in the future. Its construction cost is almost the same as the ballast track. However, since it needs almost no maintenance, it is more economical than the ballast track. Furthermore, the track formation width is narrower compared to the ballast track.

(2) Issues

1) Small Supporting Base

The track construction, track maintenance, and track material manufacturing industries in South Africa have a small base. Investment in track construction and track maintenance has been limited until now. The scale of the supporting base is sufficient at this time; however, when TRANSNET and PRASA increase investment in track construction and track maintenance, even if the supporting base has the technologies to meet the demand, it will have shortage of technical personnel, track maintenance equipment, and business capital.

2) Raising the Education Level of Employees

Since the skill level of local workers is low, many companies see the need to raise the level of technical personnel, such as enhancing technical capabilities through OJT. Some companies have also established training departments to enhance the technical capabilities of employees.

3) Shortage of Construction Equipment

Without the specialized equipment and machinery, track construction and track maintenance cannot be carried out. The price of each unit of the track machines is high (about 15 million ZAR). Even if TRANSNET and PRASA suddenly order more track construction and track

maintenance, the machine manufacturers may have difficulty responding quickly or securing sufficient funds.

4) Fund Shortage

Since the railway-related market had been small until now, many companies are also small. They do not have sufficient capital to expand operation.

4.3.5 Common Issues and Solutions

(1) Shortage of Human Resources in Industries

Shortage of skilled labor and unstable orders are common issues faced by the four industries of rolling stock, signaling, electric power, and civil engineering. These are not just problems of the railway industry; they are the biggest employment-related policy issues in South Africa. While South Africa is actively taking measures in line with the National Skills Development Framework (NSDF), this is also a chance for Japan to be proactive in offering assistance.

Besides public assistance, as Japanese companies move forward with localization, they will contribute to the training of human resources on a company basis. This is conducive not only to favorable BEE evaluation but also to the cultivation of a trustful relationship with local companies.

(2) Unstable Orders

Instability in orders is common to the four industries. Ultimately, TRANSNET and PRASA are the only two companies placing orders to the railway industry in South Africa. Since their procurements are not regular, the market is not stable, making it difficult for the manufacturers and related businesses to make business plans. In fact, even when the Study Team asked local manufacturers about the market sizes of their industries during our interviews, most said that it is difficult to give an answer to “market size” in a conventional sense because it all depends on whether there is any bidding or not.

Regarding this issue, the South African government also recognized that “Short-term and unstrategic procurement practices in relation to major areas of public capital expenditure, which both raises costs and limits prospects for localization.” It is hoped that PICC will pursue strategic procurement in the future.

(3) Shortage of Corporate Funds

Local companies, which made up the supporting industries, are mostly small and medium-sized companies. Even when there is a chance for large-scale bidding, these companies may be constrained in their response due to shortage of funds. In light of this, the Department of Trade and Industry is working to enhance its corporate incentive system. It will also be a very effective strategy for Japanese companies to offer financial assistance when they form partnerships with local companies. This is a strategy that shares commonality with assistance in human resources training mentioned in (1) above.

(4) Requirement for Localization

The requirement for high-level localization in the rolling stock industry is also a big challenge. It is necessary to conduct a comprehensive review of the BEE and PPPFA systems, and gather and analyze information to find solutions. In this regard, it is extremely important to form alliances with local companies.

4.4 Current State of Job Skills Training and Issues

4.4.1 Education System in South Africa

Public education in South Africa uses a 7-5-4 system. As shown in Table 4-17, it is composed of 7 years of primary school, 5 years of high school, and 4 years of university. They are divided into three categories: General education, Higher Education (HE), and Further Education and Training (FET). General Education is under the jurisdiction of the Department of Basic Education (DBE), and HE and FET are under the jurisdiction of the Department of Higher Education and Training (DHET). The DHET also established the Sector Education and Training Authority (SETA) to support occupational training for different sectors.

To complement public education, especially occupational training, the in-house education at companies and private educational providers play an important role.

Table 4-17 Educational System in South Africa

Age	Class		Grade	Remarks
—	Non-Compulsory Education	Higher Education	Master 3	・At the end of Grade 12, a student will take a Matric examination. If the student passes the examination, then he/she can graduate from high school and obtain the qualification to enter a university. ・A student over 16 years old can attend the FET (no other prerequisites).
			Master 2	
			Master 1	
			Bachelor 4	
			Bachelor 3	
			Bachelor 2	
			Bachelor 1	
18		High School	Grade 12	
17			Grade 11	
16			Grade 10	
15	Compulsory Education		Grade 9	
14			Grade 8	
13		Primary School	Grade 7	
12			Grade 6	
11			Grade 5	
10			Grade 4	
9			Grade 3	
8			Grade 2	
7			Grade 1	

Source: Compiled by Study Team

(1) Jurisdiction of the Department of Basic Education (DBE)

DBE is in charge of primary school and high school. The students are divided into 12 grades, from Grade 1 (age 7) to Grade 12 (age 18). However, compulsory education is only offered up to Grade 9. At the end of Grade 12, students take the Matric examination. If they pass, they can graduate from high school and be qualified to attend universities and FET.

According to the results of the national assessment for language and mathematics taken by students in Grade 3, Grade 6, and Grade 9, only 27–38% of the students obtain the minimum acceptable marks. DBE aims to raise the percentage of students to at least 60%.

However, many students drop out of the compulsory education without having acquired the necessary basic skills for employment. This is a reason for the high unemployment rate[1].

[1] Based on local interviews of private education and training providers

(2) Jurisdiction of the Department of Higher Education and Training (DHET)

1) Higher Education (HE)

The universities in South Africa are classified into the traditional university, university of technology, and comprehensive university for teachers. They are similar to the university, technical university, and teacher's college in Japan but there are also differences[2]. South Africa has 23 universities, including 11 traditional universities, 6 universities of technology, and 6 comprehensive universities.

2) Further Education and Training (FET)

Fifty FET colleges have been established to provide Vocational and Continuing Education and Training (VCET) to students upon their graduation from university.

3) Sector Education and Training Authority

The Sector Education and Training Authority was established in 1998 to unify under DHET the education and training that had been carried out independently by each industry until then.

According to SETA, an estimated 4.3 million people are currently unemployed. More than half of the graduates who completed 12 years of education do not have sufficient occupational skills to get work in any industry.

At present, 23 industries have established SETA[3]. The Transport Education and Training Authority (TetaSETA) was established for railway-related industries. The TRANSNET Training Board was established under TetaSETA as one of the committees. For the manufacturing-related industries, the Manufacturing, Engineering and Related Services Sector Education and Training Authority (MerSETA) was established.

(3) Education and Training at Private Companies

Immigration of artisans overseas, aging workforce, and shortage of newly hired after the abolition of Apartheid have contributed to a shortage of skilled workers in both the public and private sectors, causing a big problem. Besides the abovementioned FET, many companies are providing education in-house[4]. Such in-house education is often administered by providers specialized in education and training.

The abovementioned FET is for people seeking employment. As for in-house education, it is often a venue for providing the necessary reeducation and retraining of experienced workers[5]. The SETA is responsible for checking the contents of job training plans and monitoring their implementation.

In the railway sector, TRANSNET has established the School of Engineering (SOE) and PRASA has established the Training Academy to provide job training.

SOE has about 2,100 students. It allocates approximately 18 million ZAR annually into job training. It also commissions GE, EMD, and other companies as well as RIBS University (Johannesburg), Regenesses University (Midrand), and University of Pretoria to provide part of its education program[6].

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[2] See the following URL for details.
http://www.ieasa.studysa.org/resources/Study_SA_11/In%20leaps%20and%20bounds%20Growing.pdf

[3] A proposal to consolidate 21 industries has been submitted (as of October 2012).

[4] The Study Team interviewed over ten companies. Most of them have some kind of in-house training.

[5] Based on local interviews of over 10 manufacturers

[6] Based on local interviews at SOE

SOE offers education not only to TRANSNET but also to PRASA and railway operators in the Zambia Railways, National Railways of Zimbabwe, Mozambique Ports and Railways, Swaziland Railway, and Botswana Railways[7].

At the PRASA Training Academy, about 250 people received training. The education program covers both existing technologies and new technologies. As an example of the latter, the Siemens provided education and training to 130 technical workers and 70 operational staff when it delivered a new signaling system[8] to PRASA.

As mentioned in 2.2.2(4)5), pursuant to the Skills Development Act (SDA) and Skills Development Levies Act (SDLA), employers who meet certain conditions must pay 1% of its annual payroll amount to a SETA as skills development levies (SDL). If SETA accepts the plans and the education and training results that an employer reports, the employer can get a refund of some of the SDL. Apart from this, SETA also gives out grants. Of course, implementation of education and training pursuant to the SDA is beneficial to the BEE score.

4.4.2 Skills Qualification System

Solving the unemployment problem is the most urgent issue in South Africa. In this backdrop, the Skills Development Act was enacted in 1998[9]. In accordance with this law, the National Skills Development Strategy (NSDS) and the Accelerated and Shared Growth Initiative for South Africa (ASGISA) explained in 2.2.2(1) are being implemented.

As explained above, both the public and private sectors are devoting great efforts to job training. From the employment promotion point of view, it is necessary to accredit objectively acquired skills. For this reason, the South African Qualification Authority (SAQA) was established as a public skills qualification organization to provide official certification in accordance with the National Qualifications Framework (NQF). Table 4-18 shows the NQF levels and education system.

In this way, if the job skill is objectively qualified, a job seeker will have greater possibility. The qualification is also useful for employers in understanding the capabilities of the job seeker. However, from an employer's point of view, there is also the drawback that an employee may leave for better compensation after the company has used its financial resources to sponsor the employee to receive education and training to acquire the qualification. As a countermeasure, a local manufacturer is said to be giving better compensation to employees who become certified[10].

The certification of qualification is conducted by SAQA through SETA. However, since it takes about half a year (as in September 2012) between the completion of education and training and the certification, the process of certification shall be sped up.[11].

[7] Same as above
[8] Based on local interviews at PRASA
[9] See 2.2.2(4)5) "Skills Development"
[10] Based on local interviews at a railway rolling stock material manufacturer
[11] Based on local interviews at TRANSNET

Table 4-18 NQF Levels and Education System

NQF Level	Band	Qualification Type
8–10	Higher Education and Training	Post-doctoral research degrees Doctorates
7		Masters degrees Professional Qualifications Honors degrees
6		National first degrees Higher diplomas
5		National diplomas National certificates
4 3 2	Further Education and Training	
1	General Education and Training	Grade 9 National certificates

Source: SAQA website
[http://www.saqa.org.za/show.asp?include=structure/nqf/overview01.html#1.]

4.4.3 Issues in Job Skills Training

In addition to the drain of skilled engineers to other countries and the retirement of older workers, the training and supply of new personnel have also been slow. The scarcity of human resources is the biggest problem facing the railway industry in South Africa. This is, almost without exception, the concern that the Study Team heard in interviews during the Survey, no matter whether it was the public or private sector, or what type of business.

Under such circumstances, South Africa is actively promoting the National Skills Development Strategy, as seen above. In recent years, there is strong realization of the importance to train instructors for education and training. In our interview at DOT, the expression “to train teachers’ teachers” for the railway industry was used to emphasize the importance of teaching personnel. In reality, as shown by the examples of SOE and Training Academy, respectively, TRANSNET and PRASA are employing not only internal resources but also soliciting the help of other manufacturers and universities. This underscores the need for nurturing teaching personnel.

Specifically, vigorous efforts are being made to establish the first railway-engineering faculty in South Africa at the Vaal University of Technology in Gauteng province. South Africa’s railway sector is growing and it is expected to create high demand for technical personnel to work in operation, maintenance, and so on. Given the challenge to supply high-quality human resources to meet the demand, the University will open South Africa’s first railway faculty for the 2014–2015 academic year. Professor Ndege at the University is spearheading the preparation.

The University is aware of the success of the JICA project at Jomo Kenyatta University of Agriculture and Technology in Kenya[12]. It has high expectation for Japan to be proactive in offering assistance to the opening of the new faculty[13].

[12] Technical cooperation project (human resources development department) ID (former)5151061E0, cooperation period: 1978 - 2000.
[13] Based on local interviews (Vaal University of Technology and DOT)

4.5 State of Locomotive Maintenance

To understand the issues pertaining to the maintenance of rolling stock, the Study Team conducted a survey from August 28 to September 17 of 2012 and interviewed concerned parties at the car depots of TRANSNET Rail Engineering (TRE) where the electric locomotives delivered by Mitsui/Toshiba are maintained. The survey results are as follows:

4.5.1 Common Factors in TRE Maintenance

(1) Overview of TRE

TRANSNET purchased locomotives for the use of its affiliated company, TRANSNET Freight Rail (TFR). Approximately 1,400 units of electric locomotives between 1969 and 1990 and approximately 1,100 units of diesel electric locomotives between 1965 and 1993 were procured by TRANSNET. In line with its policy of using locomotives for 50 years, TFR has been using Series 6E (age of locomotives approximately 40 years) and Series 7E (age of locomotives approximately 30 years) for a long time.

According to the 2011 TFR annual report, TFR is anticipating increase in freight transport volume in the next four years (9.0% increase in the Iron Ore Line and 3.2% in general freight). It has purchased about 180 units of the latest Series 19E and 15E electric locomotives with an AC traction system and about 150 units of the Class 43 diesel electric locomotives.

Besides maintaining these locomotives, freight trains, and other equipment used by TFR, TRE also maintains PRASA coaches (for commuter trains and long-distance passenger trains).

Figure 4-20 are examples of electric locomotives.

(a) Series 19E electric locomotive

(b) Series 15E electric locomotive

Source: Photos taken by Study Team

Figure 4-20 Examples of Electric Locomotives

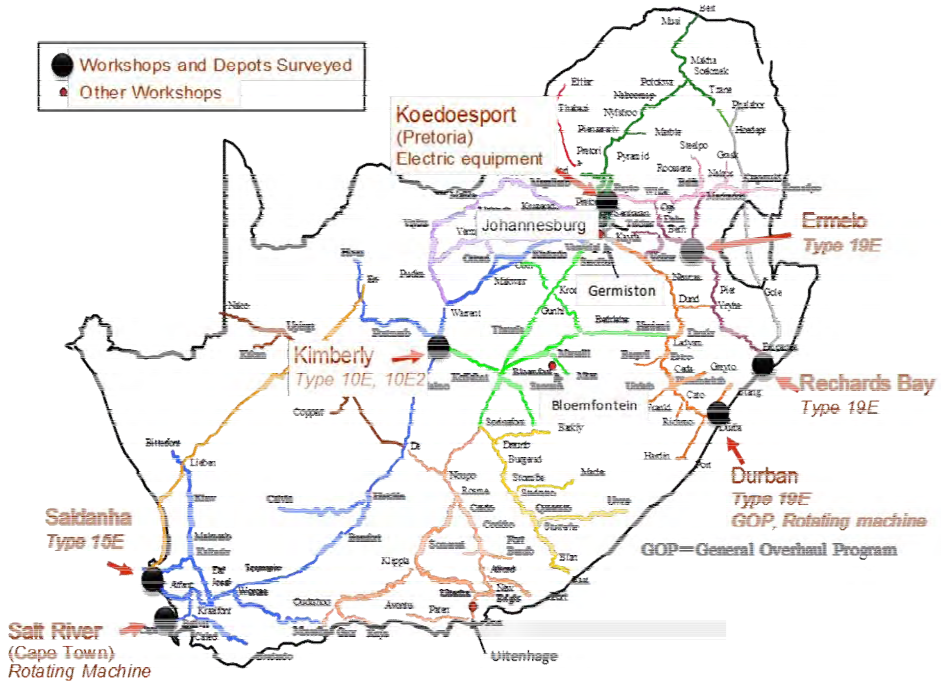
(2) Depot System and Subjects of Survey

TRE has depots at 132 locations in South Africa. Besides storing trains, 27 locations have inspection and repair functions. Among them, the ones at Koedoespoort, Broemfontein, Durban, Salt River, Germiston, and Uitenhage are workshops that can perform overhaul, upgrade, and refurbishment. The other 21 depots conduct regular inspection.

Each of the 21 depots performing regular inspection is responsible for the maintenance of a certain type of locomotive. Depending on the workload and type of locomotive, a regular-inspection depot may contract with a workshop to have the work done on a certain locomotive or equipment. The workshops do not have a specific locomotive type for which they are responsible. They carry out maintenance and overhaul based on the orders received from the depots and outside customers.

Among the 21 depots that perform regular inspection, the Study Team conducted survey at the

depots in Kimberley (Series 10E and 10E2), Richards Bay (Series 19E), Ermelo (Series 19E), and Saldanha (Series 15E) where regular inspection of the electric locomotives (Series 10E, 10E2, 19E, and 15E) delivered by Mitsui/Toshiba is carried out. We also conducted survey at the workshops in Koedoespoort, Salt River, and Durban that are currently responsible for the overhaul of electric equipment of Series 10E because they will also be responsible for the overhaul of electric equipment of Series 19E and 15E in the near future. Figure 4-21 shows the surveyed locations.



Source: Compiled by Study Team

Figure 4-21 Workshops and Depots Surveyed

(3) Classification and Contents of Maintenance

Although the cycle time may differ slightly depending on the locomotive type, Table 4-19 shows the regular inspection (Shed) at TRE depots (shown also in 4.1.1 Table 4-2). Figure 4-22 shows the condition of regular inspection.

Table 4-19 Cycle of Each Shed, Inspection Contents, and Time Required

Type of inspection	Cycle	Contents	Time required
A-Shed	1 month	Appearance inspection of car body Appearance inspection of equipment Cleaning	4 hours
B-Shed	6 months	Inspection items of A-Shed: Inspect condition of high-voltage wire connection Inspect oil	1 day
C-Shed	1 year	Inspection items of B-Shed: Change oil Calibration Adjust meters Adjust brakes	2 days

D-Shed or MOP(Mini Overhaul Program)	6 years (3 years for Series 19E and 15E)	Overhaul by removing the electric equipment and mechanical equipment (including bogie) from the car body	1 month
D-Shed or GOP (General Overhaul Program)	12 years	Overhaul by removing the electric equipment and mechanical equipment (including bogie) from the car body Refurbishment Repainting of car body, etc.	2 months

(Note) "Shed" is used to indicate the type of inspection.
Source: Compiled by Study Team

(a) Body Ascending

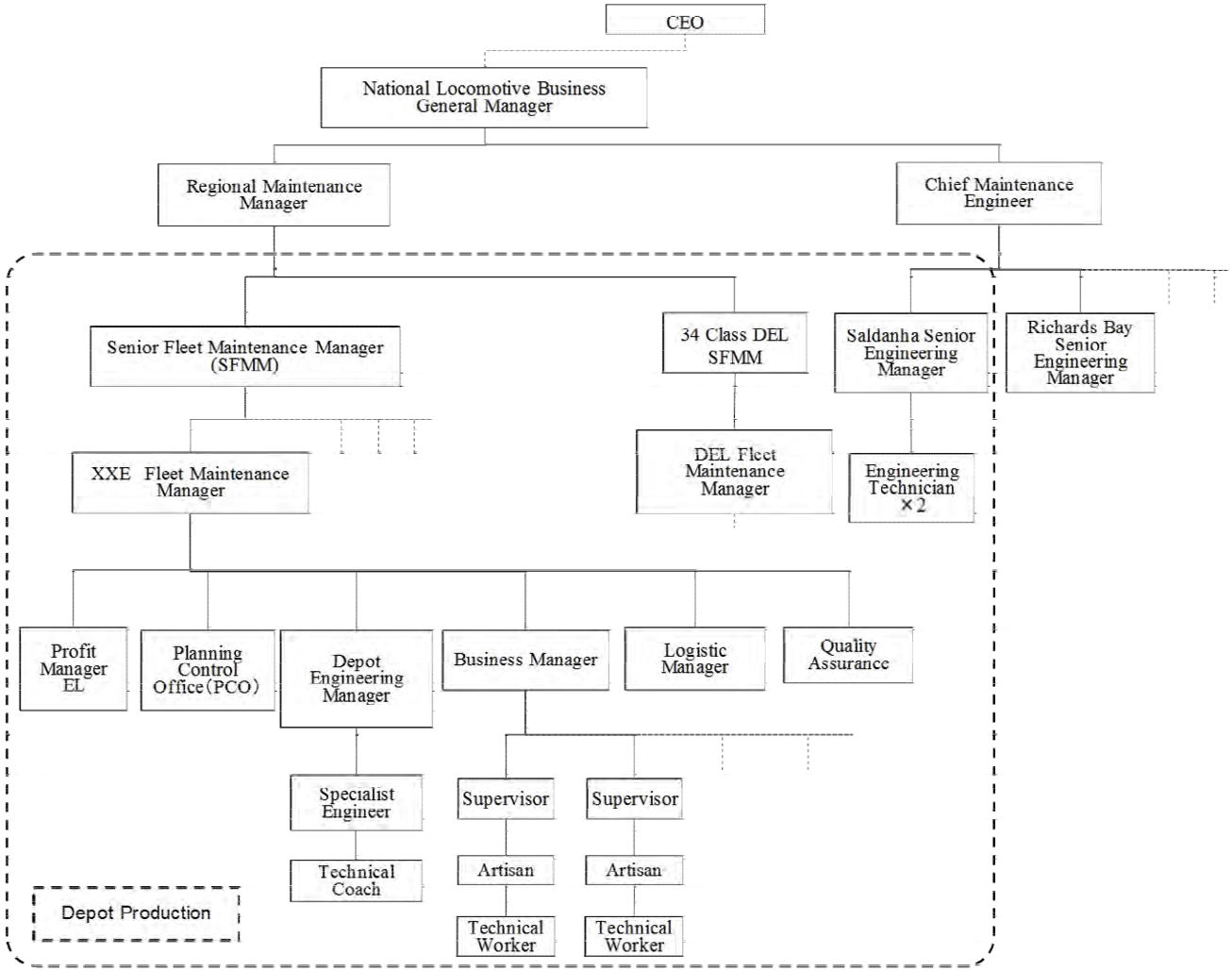
(b) Maintenance of Axle and Wheel

Source: Photos taken by Study Team

Figure 4-22 Conditions of Regular Inspection

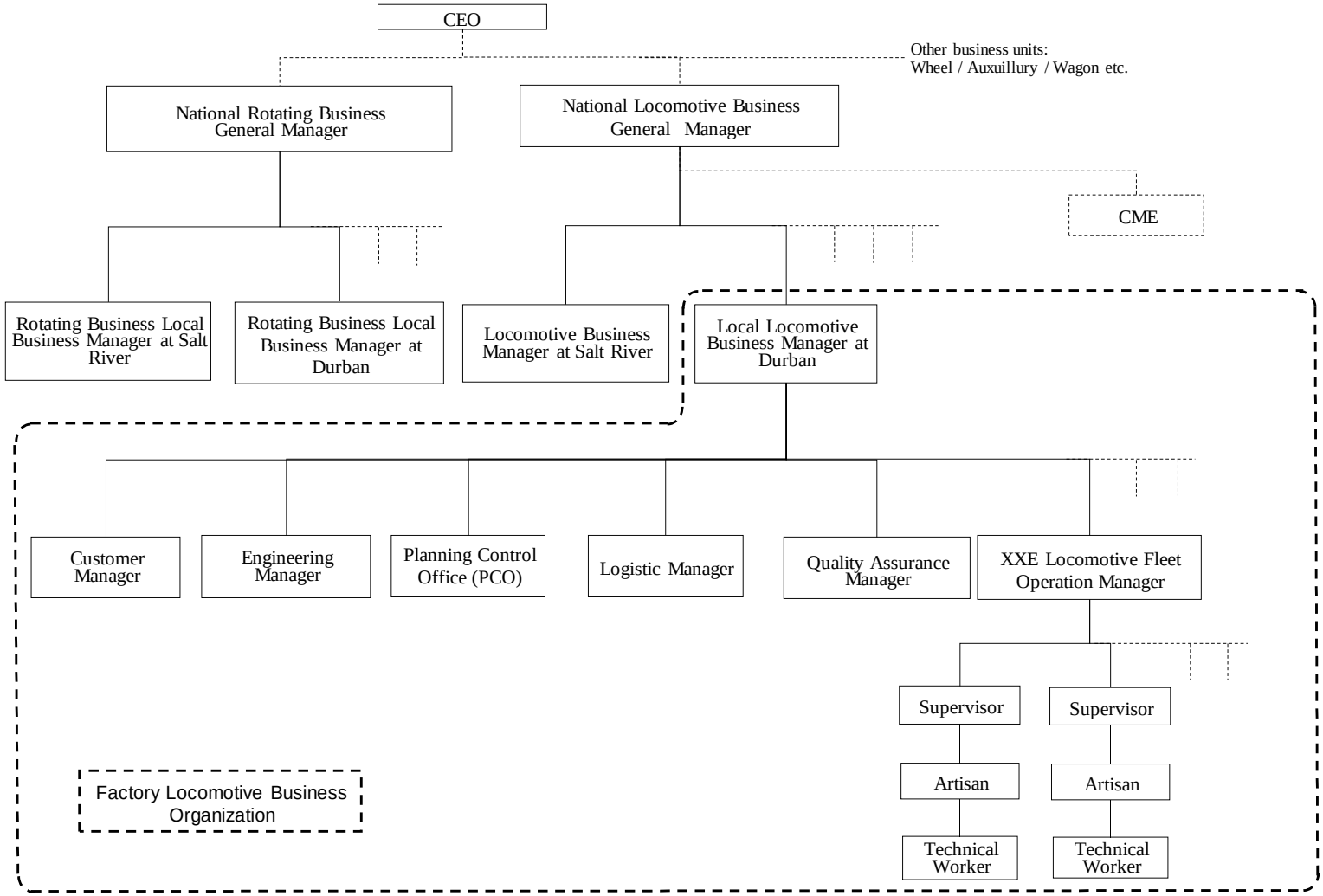
(4) Maintenance System

The General Manager at the headquarters is in charge of the maintenance of locomotives nationwide. Under the General Manager, there is a Senior Fleet Maintenance Manager (SFMM) for each locomotive type. Figure 4-23 is an organization chart of the workshop and Figure 4-24 is an organization chart of a depot. Under the SFMM, there is a Fleet Maintenance Manager in the depot for each type of locomotive. Under the Fleet Maintenance Manager, there is a Business Manager in charge of maintenance works.



Source: Compiled by Study Team

Figure 4-23 Organization Chart of Workshop

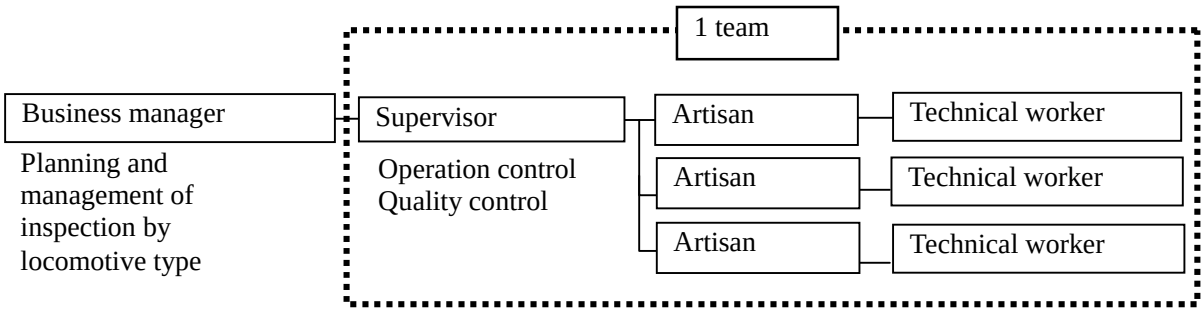


Source: Compiled by Study Team

Figure 4-24 Organization Chart of Depot

Figure 4-25 shows the system for implementing general maintenance in a depot. A supervisor under the Business Manager forms a team to perform maintenance works.

Depending on the type of locomotive that the depot is responsible for maintaining, a depot generally has over three maintenance and inspection teams. Each team is made up of 7–10 members, including a supervisor, artisans, and technical workers.



Source: Compiled by Study Team

Figure 4-25 Composition of Maintenance Team

(5) Planning and Implementation of Maintenance Works

TRANSNET group is using the Systems, Applications and Products in Data Processing (SAP) to manage the production, cost, and training history of the company across-the-board.

Maintenance works are planned using SAP. It automatically prepares a weekly work plan for each Shed. Based on this plan, the Fleet Manager or Business Manager prepares an implementation plan and inputs it into the SAP. Based on this weekly implementation plan, the Production Control Office (PCO) of each depot outputs a detailed daily work plan and the necessary work instructions and checklist for each Shed and gives them to the Business Manager and Supervisor responsible for implementing the maintenance. Based on the information and instructions of the supervisor, the artisans and technical workers carry out the maintenance works.

After the maintenance works are finished, the workers send the work results to PCO and PCO inputs the work results into the work records.

(6) Managing Work Records

The workers perform maintenance works according to the checklist that PCO outputs from the SAP. When the works are complete, the supervisor conducts a secondary inspection of only the key items.

When there is a problem, the TRE workers and engineers will work together to identify the cause. When it is necessary to replace component parts, TRE will make a request to PCO and pay for the component parts. PCO will issue the work procedures and the workers under an artisan will make the replacement following the instructions of an engineer or supervisor. After the replacement, the engineer will compile a Non Conformance Report (NCR) and submit it to PCO. PCO will input the report into SAP. Based on this information, the 3-month rolling stock record sheet and check sheet, which contain 3 months of work records and failure records issued by PCO, are made into a database to enable the engineers, supervisors, and workers to perform searches. The engineer will use the 3-month rolling stock record sheet to analyze the characteristics of a particular car and identify the key items for the next maintenance. However, no analysis of the cause of failure is performed.

(7) Managing Work Process

Every morning, the supervisor or manager will conduct a work meeting based on the detailed daily work plan generated by PCO to follow up on any adjustment or delay in the work process.

(8) Work Instructions

Based on the detailed daily work plan generated by PCO, the supervisor gives oral instructions to workers on the day's works in the morning meeting every day.

(9) Education and Training

TRE has a system called the School of Engineering (SOE), which provides education in three phases, as shown in Table 4-20. The attendance record is managed by SAP.

Table 4-20 SOE system of TRE

Trainee	Contents of education
Before joining the company	- Students are recruited and offered education before entering the company. They received stipend for living expenses during the training. Upon completion of training, they are admitted to TRE. The ones who choose to join other companies are required to return the stipend for living expenses.
Within 3 years after being hired	- It is an education curriculum offered to workers within 3 years after being hired. The contents of education include general education on rolling stock system (phases 1→2→3→4, a total of 173 days) and specific curricula on locomotives.
Current worker	- Individual training programs on special skills (welding, crane, soldering, etc.) are offered.

Source: Compiled by Study Team

Figure 4-26 shows the scenes of a lecture and practical training session.

(a) Lecture

(b) Practical training session

Source: Photos taken by Study Team

Figure 4-26 Scenes of Training at SOE

There is no refresher courses after the completion of training, only on-the-job training at the workplace. Therefore, there is no way to verify if the skills have been retained or not. Among the workers, however, the candidates for manager positions receive manager education from internal and external instructors.

(10) QC Activities

Quality control (QC) activities are carried out by each section at the workplace. As shown in Figure 4-27, each section is carrying out activities, as shown by the contents of activities under the themes “Quality,” “Speed,” “Cost,” and “Safety” posted on the walls at the sections’ workplaces.

Source: Photo taken by Study Team

Figure 4-27 Postings of QC Activities

4.5.2 Current State and Challenges of Various Workshops and Car Depots

(1) Current State

We conducted survey at three workshops in Koedoespoort, Salt River, and Durban and at four depots in Kimberley, Richards Bay, Ermelo, and Saldanha.

Every site where we conducted the survey had adequate functions (workspace, number of pits, and number of cranes) necessary for performing maintenance. The workshops are doing overhauls of rotating equipment (main motor) and have adequate facilities to do repairs. However, the workshops have facilities for DC motors but no facilities at all for AC traction motors. Each depot has facilities to lift the car body and enough pits. However, the recommended replacements of electric equipment on a regular basis and other preventive maintenance have not been carried out.

Table 4-21 is a comparison of the main items.

Table 4-21 Maintenance Conditions at Various Workshops and Depots

(a) Workshops

	Items of Survey	Koedoespoort Workshop	Salt River Workshop *Only surveyed the rotating equipment building	Durban Workshop *Only surveyed the locomotive rehabilitation building
Overview	Number of buildings for rolling stock warehousing	Overhaul/repair: 1 building Series 16E→Series 18E refurbishment: 1 building Series 43 assembly line: 1 building Testing line: 1 building	Rotating equipment reassembling line: 2 buildings Rotating equipment storage: 1 building	Repair line: 4 buildings Painting line: 1 building Warehouse: 1 building
	Number of electric locomotives in possession	The workshops are not assigned any particular rolling stock because they are rehabilitation workshops. They perform MOP and GOP according to the requests from depots.		
		Responsible for: [EL] Series 6E, 7E, 10E, 10E1, 10E2, and 18E [DEL] Class 34, 37, and 38	Responsible for: [EL] Series 9E [DEL] Class 34 Has DC motor made by GE in Africa	Responsible for: [EL] Series 7E, 7E1, 7E2, 7E3, 8E, 10E, 10E1, and 10E2 [DEL] None
	Usage of electronic parts	Has COE Control of old locomotives/maintenance of high-voltage equipment. Can perform repairs	No COE Does not handle most electric equipment	Does not handle Has repair shop for electric equipment but does not handle electronic equipment
	Work contents			
	A-, B-, C-Shed	No	No	No
	D-Shed	Yes	Yes	Yes
	Overhaul of control equipment	Yes	Some(mainly outsource)	Some (request other workshops to perform some works)
	Overhaul of high-voltage electric equipment	Yes	Some(mainly outsource)	Some (request other workshops to perform some works)

	Items of Survey	Koedoespoort Workshop	Salt River Workshop *Only surveyed the rotating equipment building	Durban Workshop *Only surveyed the locomotive rehabilitation building
	Overhaul of bogie	Yes	Yes	Yes
	Overhaul of motor	Yes	Yes	Yes
	Overhaul of car body	Yes	Yes	Yes
Organization	Number of employees	290 workers for rotating equipment alone	120 workers for rotating equipment alone	215 workers (locomotive rehabilitation workshop alone)
	Name and number of Organizations	Generally as shown in Figure 4-, may differ by workshop		
Facility-related	Facility/equipment for maintenance			
	Wheel reprofiling machine	Yes	Yes	Yes
	Sheet metal painting facility	Yes	Yes	Yes
	Motor testing facility	Yes	Yes (DC motor only)	Yes (DC motor only)
	Testing facility for high-voltage electric equipment	Yes	No	No
	Testing facility for control-type electric equipment	Yes	No	No
	Equipment cleaning facility	Yes	Yes	Yes

	Items of Survey	Koedoespoort Workshop	Salt River Workshop *Only surveyed the rotating equipment building	Durban Workshop *Only surveyed the locomotive rehabilitation building
	Washing machines (purpose and scale)	Dry ice washing machine, cleaning machine, cleaning with water at high pressure	The rotating machine removes resin using water with high-pressure and grinding machine	Dry ice washing machine, cleaning machine, cleaning with water at high pressure
	Hydraulic Press	No	Yes	No (has wheel in workplace)
	Welding	Has large welding facility	Same as left	Small scale, has manual welding facility
	Maintenance facility for AC equipment	No		
	Other facilities	—	Except those for the manufacture of electric motor frame, all manufacturing facilities for rotating equipment are available. Rehabilitation covers the entire electric car, except the car body.	All other facilities for manufacturing rotating equipment are available except for those required for the manufacture of electric motor frame (workplace for rotating equipment).
Environment	Number of dust-proof buildings	No		
	Electrostatic Environment	No electrostatic area		
Maintenance function	Drawings, Manuals	Can use the IEM system to access drawings and manuals from the TFR server		
	Maintenance Plan, Overhaul Plan	Business Manager uses SAP to prepare OH schedule.		

	Items of Survey	Koedoespoort Workshop	Salt River Workshop *Only surveyed the rotating equipment building	Durban Workshop *Only surveyed the locomotive rehabilitation building
Evidence-related	Record of scheduled maintenance and inspection, inspection report, check sheet, fault data, and record of repairs	Stored in binders by individual vehicle at the Production Planning Office (PCO). Fault data are inputted into SAP.		
	Record and notice of analyses and countermeasures for failures	(1) When rolling stock malfunctions: Verify the failure -> The engineer and supervisor will investigate the failure and review countermeasures->Record the results of countermeasures on Non Conformance Report->Submit the report to PCO where the data is inputted into SAP		
		No department to facilitate peer group review of the viability of countermeasures	—	No department to facilitate peer group review of the viability of countermeasures
		—	—	(3) Notification of repairs: QA prepares the Non Conformance Report (NCR). Worker groups conduct quality meeting every week to investigate the causes of failures and implement countermeasures.
	Trouble-shooting	Each workplace has its own trouble-shooting information but no summarized information as a whole.	Same as left	IEM is storing trouble-shooting information.
Maintenance team	Map of skill	Yes		

	Items of Survey	Koedoespoort Workshop	Salt River Workshop *Only surveyed the rotating equipment building	Durban Workshop *Only surveyed the locomotive rehabilitation building
	Plan of education and training	There is an SOE inside the workshop. SAP is used to make education and training plans. The SOE prepares and implements education plans.	Same as left	The SOE is on the workshop premises in the Umbilo area of Durban. SAP is used to make education and training plans. The SOE prepares and implements education plans.
	Record of education and training	Store education record in the SAP		
	Map of techniques such as welding, soldering, crane, forklift	Submit special education plan using SAP and provide education according to the plan. Store record in SAP.		
	Acquisition of qualification	No particular qualification. Only certificate of completion		
	Management by Target	Use SAP to manage the skills target		
	Others	The SOE provides education to newly hired and current employees. The SOE curriculum for current employees includes general education on rolling stock system (PHASE1→2→3→4, total of 173 days) in the first year upon joining the company and individual curriculum for each locomotive type and curriculum of special skills.		

	Items of Survey	Koedoespoort Workshop	Salt River Workshop *Only surveyed the rotating equipment building	Durban Workshop *Only surveyed the locomotive rehabilitation building
Condition of repaired parts	Kinds	Almost all the electric and mechanical parts of the old locomotives are repaired and stored.	The rotating equipment, MA/MG, and compressors of old locomotives that can be repaired by the workshop are stored at the workshop. The GE motor parts are stored by GE at the Koedoespoort workshop.	Stores parts for the overhaul of locomotives and replacement parts. Does not store small equipment, such as electrical devices, etc.
	Condition of storage	Used parts are stored together with new parts.	Same as left	Mainly new parts
	Others	Can conduct detailed study and restoration of circuit boards	—	—
Condition of spare parts	Kinds	At COE, the main parts are stored in the warehouse as the assets of each manufacturer. Whenever TRE needs to use the parts, it will pay for them. The manufacturer will then replenish the parts.	The workshop stores parts for the rotating equipment. The GE motor parts that have long lead-time are stored at Koedoespoort. The workshop will only request the necessary quantity.	The workshop stores mainly spare parts for the overhaul of the locomotive as a whole. The spare parts for individual equipment are stored at RM, RSE, and electrical equipment shops.
	Condition of storage	The overall storage condition is not clear.	Organized and stored in large warehouse	Organized and stored in large warehouse
	Name of company of procurement	Old locomotive parts are mostly procured from local manufacturers and distributors.	The workshop obtains most of the Series 9E parts from ACTON, diesel electric locomotive parts from GE, and bearings from NSK or NTN in Japan.	The workshop purchases most of the spare parts through local manufacturers and distributors. Only the spare parts of Series 10E are bought through ACTON.

	Items of Survey	Koedoespoort Workshop	Salt River Workshop *Only surveyed the rotating equipment building	Durban Workshop *Only surveyed the locomotive rehabilitation building
Outsource	Name of company of procurement	Various locomotive manufacturers, local manufacturers, and distributors	The spare parts of rotating equipment are mostly bought from ACTON and GE. The others are from manufacturers and distributors in South Africa. Bearings are bought from NSK and NTN in Japan.	Only the spare parts of the rotating equipment of Series 10E are purchased from ACTON. The others are procured from local manufacturers and distributors in South Africa. The pantograph is from its RSE department and Siemens. The VESVCB is from Siemens and ACTOM. The compressors are from its RM department. The brakes are from its RSE department. The braking resistors are from Telema. Some of the electric parts are from Mitsui.
	Name of company doing inspection	TRE does the inspection but depending on its workload, it might ask local manufacturers or distributors to do the inspection. They are ACTON (rotating equipment), Electra (refurbishment of the IBGT of Series 10E), etc.	The inspection of rotating equipment is mostly done by ACTON and GE. The others are inspected by local manufacturers and distributors in South Africa.	The workshop asks ACTON to inspect the rotating equipment of Series 10E and 10E2 and local manufacturers and distributors to inspect the others. Pantograph: RSE and Siemens. VESVCB: Siemens and ACTOM. Compressor: its RM department. Brake: its RSE department. Braking resistor: Telema. Some electric parts: Mitsui.

	Items of Survey	Koedoespoort Workshop	Salt River Workshop *Only surveyed the rotating equipment building	Durban Workshop *Only surveyed the locomotive rehabilitation building
	Kind of equipment for repair to be outsourced	Toshiba asks TRE to repair the motors of Series 19E. It will be done at Koedoespoort. TRE does the repairs of the others but depending on the workload and cost, it might ask local manufacturers or distributors to do the repair.	The workshop does not outsource repairs of the rotating equipment of old locomotives. If the workload is too high, it will contract the work to other workshops in the company.	The workshop only asks ACTON to repair Series 10E. It does not outsource the others.
	Name of company doing the repair	ACTON (rotating equipment), Electra (refurbishment of IBGT for Series 10E), etc.	The workshop mainly asks ACTON and GE to do the repair of rotating equipment. The others are repaired by local manufacturers and distributors in South Africa It uses NSK and NTN for repairing the bearing.	For the repair of rotating equipment, the workshop only purchases parts from ACTON for Series 10E and 10E2. The others are purchased from local manufacturers and distributors in South Africa. ＜Main companies for repairs＞ Pantograph: its RSE department and Siemens. VESVCB: Siemens and ACTOM. Compressor: its RM department. Brake: its RSE department. Braking resistor: Telema. Some electric parts: Mitsui

(b) Depots

	Items of Survey	Kimberley Depot	Richards Bay Depot	Ermelo Depot	Saldanha Depot
Overview	Number of electric locomotives in possession	[EL] Series 6E, 7E, 7E2, 8E, 10E, 10E2, and 18E [DEL] Class 3, 34, and 35 Approximately 195 locomotives	[EL] Series 7E1, 7E3, 7E4, 11E, and 19E [DEL] Class 34, 35, 36, 37, and 39 Approximately 313 locomotives	[EL] Series 10E and19E [DEL] Class 34 and 37 Approximately 224 locomotives	[EL] Series 9E and 15E [DEL] Class 34 and 43 Total of 156 locomotives
	Usage of electronic parts	Has COE Can maintain and repair the control equipment of old locomotives	No COE Can maintain and repair some high-voltage equipment of old locomotives	No COE Can maintain and repair some high-voltage equipment of old locomotives	No COE Can maintain and repair from high-voltage equipment to control system of old locomotives
	Work contents				
	A-, B-, C-, D-Shed	Yes	Yes	Yes	Yes
	Overhaul of control equipment	Yes	No	No	Yes
	Overhaul of high-voltage electric equipment	Yes	Yes	Yes	Yes
	Overhaul of bogie	Some (mainly outsource)	Some (mainly outsource)	Some (mainly outsource)	Some (mainly outsource)
	Overhaul of motor	Some (mainly outsource)	Some (mainly outsource)	Some (mainly outsource)	Some (mainly outsource)
	Overhaul of car body	Some (only replacement of equipment)	Some (only replacement of equipment)	Some (only replacement of equipment)	Some (only replacement of equipment))

	Items of Survey	Kimberley Depot	Richards Bay Depot	Ermelo Depot	Saldanha Depot
Organization	Number of employees	107 (total number of workers and managers)	N/A	N/A	100
	Name and number of Organizations	As generally shown in Figure 4-, may differ by depot			
Facilities-related	Facility /equipment for maintenance				
	Wheel reprofiling machine	No	No	Yes	Yes
	Motor testing facility	No	No	No	No
	Testing facility for high-voltage electric equipment	Yes	Yes	Yes	Yes
	Testing facility for control-type electric equipment	Yes	Yes	Yes	Yes
	Equipment cleaning facility	Yes	Yes	Yes	Yes
	Washing machine (purpose and scale)	Dry ice washing machine, cleaning machine, cleaning with water at high pressure			
	Hydraulic press	No	No	No	No (for freight train use only)
	Welding	Small welding facility (outsource large welding)			

	Items of Survey	Kimberley Depot	Richards Bay Depot	Ermelo Depot	Saldanha Depot
	Maintenance facility for AC equipment	No			
	Other facilities	—	—	—	Detailers take care of the rooftop equipment. PC has been set up to work on making Shed works paperless.
Environment	Number of dust-proof buildings	No			
	Electrostatic environment	No electrostatic environment			
Maintenance function	Drawings, manuals	Can use the IEM system to access drawings and manuals from TFR server			
	Maintenance plan, overhaul plan	Business Manager uses SAP to prepare OH schedule.			
Evidence-related	Record of scheduled maintenance and inspection, inspection report, check sheet, fault data and record of repairs	Store in binders by individual vehicle at the Production Planning Office (PCO). Fault data are inputted into SAP.			
	Record and notice of analyses and countermeasures for failures	When rolling stock malfunctions: Verify the failure→ The engineer and supervisor will investigate and review countermeasures for the rolling stock→Record the results of countermeasures on Non Conformance Report→Submit the report to PCO where the data is inputted into SAP			
		No department to facilitate peer group review of the viability of countermeasures	—	—	—

	Items of Survey	Kimberley Depot	Richards Bay Depot	Ermelo Depot	Saldanha Depot
	Trouble-shooting	Each workplace has its own trouble-shooting information but no summarized information as a whole.	Uses trouble-shooting sheet to resolve problems	Same as left	Same as left
Maintenance team	Map of skill	Yes			
	Plan of education and training	There is a SOE inside the workshop. SAP is used to make education and training plans. The SOE prepares and implements education plans.	SAP is used to make education and training plans. The SOE prepares and implements education plans.	The depot receives directions from outside personnel in charge of education and lets its trainees go to Ermelo or other designated classrooms to receive education.	The depot has set up a new SOE. It uses SAP to make education and training plans. The SOE prepares and implements education plans.
	Record of education and training	Stores education record in SAP	Same as left	Stores education record in paper form	Same as left
	Map of techniques such as welding, soldering, crane, forklift	Submit special education plan using SAP and provide education according to the plan. Store record in SAP.			
	Acquisition of qualification	No particular qualification. Only certificate of completion			
	Management by Target	Use SAP to manage the skills target			
	Others	SOE provides education to newly hired and current employees. The SOE curriculum for current employees includes general education on rolling stock system (PHASE1→2→3→4, total of 173 days) in the first year upon joining the company and individual curriculum for each locomotive type and curriculum of special skills.			

	Items of Survey	Kimberley Depot	Richards Bay Depot	Ermelo Depot	Saldanha Depot
Condition of repaired items	Kinds	The electric and mechanical parts of old locomotives are repaired and stored.	The electric and mechanical parts of old locomotives are repaired and stored. Repair of the new Series 19E locomotives is done by the manufacturer.	Same as left	The electric and mechanical parts of old locomotives are repaired and stored. Repair of the new Series 15E locomotives is done by the manufacturer.
	Condition of storage	Used parts are stored together with the new parts.			
	Others	Can conduct detailed study and restoration of circuit boards	—	—	—
Condition of spare parts	Kinds	Stores main component parts Series 18E and other old locomotives: Stores used units, including main equipment	Stores main component parts Series 19E: pantograph, others Other old locomotives: Stores used units, including main equipment	Stores main component parts Series 19E: pantograph, others Series 10E and other old locomotives: Stores used units, including main equipment	Stores main component parts Series 15E: IGBT unit, motor, main transformer (2 units), pantograph, and others Series 9E: Stores almost all units, including used parts
	Condition of storage	Stores in mid-sized warehouse	Temporarily stores in maintenance shop because the workshop is in the process of building an additional warehouse	Stores in mid-sized warehouse, some stored in a messy condition	Organizes and stores in large warehouse

	Items of Survey	Kimberley Depot	Richards Bay Depot	Ermelo Depot	Saldanha Depot
	Name of company of procurement	ACTON performs all the maintenance and repairs, including Series 10E and 7E, of rotating equipment, including the replacement of bearing. Other parts are also purchased from local manufacturers and distributors.	The electrical parts of Series 19E are procured from Toshiba. The parts procured from South Africa are purchased directly from the manufacturers. The spare parts of other old locomotives are mostly procured from local manufacturers.	Same as left	The electrical parts of Series 15E are procured from Toshiba. The parts procured from South Africa are purchased directly from the manufacturers. Most of the parts of Series 9E are procured from ACTON. The engines and other parts of DEL are procured from locomotive manufacturers.
Outsource	Kinds of parts procured	Various parts, including electrical and mechanical parts	Series 19E: rotating equipment, HSCB, and others Other old locomotives: Various parts, including electric and mechanical parts	Same as left	Series 15E: IGBT unit, motor, main transformer, and others Series 9E: rotating equipment, brake, MA/MG, thyristor, pantograph, etc.
	Name of company of procurement	Various parts are procured from local manufacturers and distributors: ACTON (rotating equipment), Knorr (brake), WabTec (electric equipment), etc. The rotating equipment of Series 10E is from ACTON and IGBT is from Electra (Italy). Since Toshiba's lead-time is long, it seldom receives any order.	Series 19E: The electric parts are procured from Toshiba. Other mechanical parts are procured directly from local manufacturers and distributors. Other old locomotives: All parts are procured from local manufacturers and distributors, ACTON (rotating equipment), Knorr (brake), WabTec (electrical equipment), and Sécheron (HSCB), etc.	Same as left	Series 15E: Toshiba (electric parts), Knorr (brake), VCB (ALSTOM), RSD (bogie), etc. Series 9E: ACTON (rotating equipment), Knorr (brake), LHM (MA/MG), ALSTOM (thyristor, diode), Siemens (pantograph), etc. DEL: Various manufacturers (engine), etc.

	Items of Survey	Kimberley Depot	Richards Bay Depot	Ermelo Depot	Saldanha Depot
	Kinds of tests and inspection to be outsourced	May outsource the inspection of individual equipment, including electric and mechanical equipment	Series 19E: plans to outsource the inspection of rotating equipment, HSCB, and others Other old locomotives: May outsource the inspection of various parts, including electric and mechanical parts	Same as left	Series 15E: IGBT unit, motor, main transformer, and others Series 9E: rotating equipment, brake, MA/MG, thyristor, diode, pantograph, etc.
	Name of company performing inspection	The various parts are handled internally at TRE. Depending on the workload, the depot may ask local manufacturers and distributors to do the inspection: ACTON (rotating equipment), Knorr (brake), Electra (refurbishment of IGBT and electrical equipment)	Series 19E: The depot asks Toshiba to inspect the electric parts and other local manufacturers and distributors to inspect the mechanical parts. Other old locomotives: The various parts are inspected internally at TRE. Depending on the workload, the depot may ask local manufacturers and distributors to do the inspection: ACTON (rotating equipment), Knorr (brake), WabTec (electrical equipment), and Secheron (HSCB), etc.	Same as left	Series 15E: Directly requests the manufacturer to do the inspection. Series 9E: ACTON (rotating equipment), Knorr (brake), LHM (MA), ALSTOM (thyristor, diode, etc.), Siemens (pantograph), etc. DEL: Various manufacturers (engine), etc.

	Items of Survey	Kimberley Depot	Richards Bay Depot	Ermelo Depot	Saldanha Depot
	Kind of equipment for repair to be outsourced	The repairs are done at Koedoespoort or Durban. When it is not possible, a public bidding is held to decide on a manufacturer.	Series 19E: Requests Toshiba to repair the electric equipment and UCW to repair the mechanical equipment during the warranty period. No decision has been made for repairs after the end of the warranty period. Other old locomotives: The repairs are done at Koedoespoort or Durban. When it is not possible, a public bidding is held to decide on a manufacturer.	Same as left	Series 15E: Requests Toshiba to repair the electric equipment and UCW to repair the mechanical equipment during the warranty period of electric locomotives. Also requests repairs after the warranty period (outside the contract). Series 9E: Salt River Workshop repairs the rotating equipment; if not possible, ACTON will be asked to do the repair.
	Name of company performing the repair	Pantograph: RSE department, Siemens, etc. Rotating equipment: ACTON. Brake: Knorr, MA/MG: LHM, Thyristor diode: ALSTOM, Power unit: Electra, etc. DEL: Various manufacturers (engine), etc.	(1) Series 19E: Toshiba and UCW (2) Other old locomotives: Pantograph: RSE department, Siemens, etc. Rotating equipment: ACTON, Brake: Knorr, MA/MG: LHM, thyristor diode: ALSTOM, Power unit: Electra, etc. (3) DEL: Various manufacturers (engine), etc.	Same as left	(1) Series 15E: Toshiba and UCW (2) Series 9E: Pantograph: RSE department and Siemens, Rotating equipment: ACTON, Brake: Knorr, MA/MG: LHM, Thyristor diode: ALSTOM, etc. (3) DEL: Various manufacturers (engine), etc.

Source: Compiled by Study Team

(2) Challenges

The Study Team identified problems and issues from the results of this Survey.

1) Problems in the Maintenance of Electric Locomotives

a) Insufficient Maintenance Facilities

The new-type electric locomotives introduced after 2008 use inverter as the driving device and an AC system. As is the case in conventional DC system, without adequate maintenance facilities, faulty parts will spread in systems on a locomotive, making it impossible to repair. Thus, it will not be possible to secure the number of electric locomotives for operation, thus seriously interrupting train operation.

TRE has sufficient facilities and experience for the maintenance of electric locomotives (EL) with a DC system and diesel electric locomotives (DEL). It also has a plan to set up facilities for AC main motors in the future. However, none of the workshops or depots has any plan to install facilities for maintaining electrical equipment of the new-type electric locomotives besides the main motor.

b) Lack of Maintenance Technology

Since all the equipment (control system and power semi-conductor) of the new-type EL uses the latest technologies, their maintenance method and diagnostic/repair method are different from the conventional locomotives. In particular, a greater part of the control system relies on software. TRE needs to acquire the latest technologies and accumulate technological expertise through technical assistance from the manufacturers. However, at this time, TRE only has contracts with manufacturers for 2–3 months training, showing insufficient cooperation with the manufacturers in acquiring and accumulating the latest technologies.

c) Lack of Maintenance Items

Similar to the conventional EL, the new-type EL also needs to have proper maintenance as recommended by the manufacturer. Through verification of the check sheet used at A–D-Shed and interviews of TRE personnel, the Study Team found that the following maintenance items have not been implemented:

- Measurement of the operating voltage (reference value) of electric relay/contactor
- Measurement of power source-related voltage
- Measurement of breaker-related cutoff standard
- Verification of the operation of sensor and other stand alone units (voltage/electric current/temperature/rotation frequency of main motor/speed)
- Verification of control sequence
- Verification of control protection sequence
- Control sequence test as the final verification before start of high voltage
- Measurement of condenser capacity and tan δ
- Inspection for soldering cracks, etc.
- Measurement of the light volume of optical fiber
- Verification of the soundness of protective circuit

The electric equipment of a locomotive has circuits to protect the equipment in case of failure in order to minimize damage. In Japan, after maintenance and before the restart of voltage to the main motor again, it is a standard procedure to verify the soundness of the protective circuit mounted on the train car. However, TRE does not have such verification procedure.

d) Verification of Mechanical Cracks

TRE verifies cracks on the bogie, main motor frame, coupler, and others by checking the color. However, it does not inspect for axle cracks, with the commonly used magnetic particle testing

and ultrasonic testing. Axle cracks can lead to derailment and other serious accidents. An example of axle damage was the derailment of a freight train on the Tsugaru-kaikyo Line in Japan on December 6, 2000. It was caused by damage to the axle.

e) Cleaning

It is necessary to clean electrical parts in order to maintain insulation and prevent poor contact.

During our survey at the Richards Bay depot, the Study Tean found that the contact points of electrical parts (IGBT unit) of the Series 19E electric locomotive were dark after about eight months in service. According to the results of our Survey conducted at various depots, cleaning was not carried out sufficiently. The inside of electrical parts of the new-type EL is inspected visually and some parts are only cleaned with a brush. Table 4-22 shows the status and issues related to the maintenance of electric locomotives.

Table 4-22 Status and Issues related to the Maintenance of Electric Locomotives

Item	New-type locomotive (AC main motor)	Old-type locomotive (DC main motor)
Maintenance facility	Has plan for main motor only	Installed
Maintenance technology	Not sufficient	Sufficient
Maintenance item	Not sufficient	Not sufficient
Testing facility	Not available	Part of it not available
Analysis of failures and causes	Not sufficient	Not sufficient
Spare parts	Not sufficient	Not sufficient

Source: Compiled by Study Team

2) Issues related to Spare Parts

a) Shortage of Spare Parts due to Long Lead Time of Overseas Procurement

It takes over 8 months for TRE to import electronic parts from overseas manufacturers, making it impossible for it to do repair quickly.

b) Inability to Manufacture or Procure due to Abolition of Spare Parts or Closure of Factories

It is not possible to manufacture or procure the necessary parts for repair if the parts are abolished or if the factory is closed.

c) Insufficient Measures to Facilitate Long-term Storage

The electronic parts of the latest electric locomotives must be stored at an appropriate area where there is protection against dust, moisture, and statics in order to prevent degradation. Their functions must be verified on a regular basis. However, TRE does not store the electronic parts properly for long term, such as storing the electronic circuit boards and others in antistatic bags.

3) Issues related to Failures

a) Insufficient Analysis of the Causes of Failures

Analyzing the causes of failures properly, such as by utilizing fault data, makes it easier to identify the causes and speed up repairs. However, even if the train stops due to failure, there is still leeway in the train operation diagram and no obligation to report the details to the government. There is an established mindset that “it’s fine as long as the repair is done.” TRE has not sufficiently utilized the fault data to analyze the causes of failures.

b) Insufficient Preparation for Trouble-shooting

It is necessary to resolve accurately and speedily the troubles when they occur so as not to interrupt the operation plan of the locomotives. As a maintenance company, TRE needs to take measures to learn trouble-shooting methods from the equipment manufacturers in order to prepare for the expiration of the warranty period.

However, TRE is relying on the manufacturers to do the trouble-shooting at this time. It has not taken any of the abovementioned measures.

c) Insufficient Effort to Enhance the Efficiency of Failure Investigation

Due to the introduction of non-contact main circuit and inverter control, the latest locomotives use many electronic devices (electronic parts). These electronic devices have complicated circuits and are equipped with black boxes. Without the help of the manufacturers, it is difficult to investigate the failures. During the warranty period, TRE is depending on the manufacturers to conduct failure investigation when the electronic equipment fails. However, manufacturers vary in their services after the warranty period. TRE shall take initiatives to ensure efficient investigation of failures after the end of the warranty period such as by adopting special testing equipment with the help of the manufacturers.

d) Insufficient Succession of Maintenance Technology and Technology Certification

TRE is taking measures to encourage veteran technicians to pass on the skills to young technicians. However, due to insecurity about losing one's job once the expertise has been taught, the succession of maintenance technology has not made much progress. Apart from this, TRE is requesting equipment manufacturers to give certification to its employees for the skills and technologies that they have acquired. Besides GE, the manufacturers have not issued any certificates.

4.5.3 Measures for Improving the Maintenance of Locomotives

(1) Assistance in Raising the Current Maintenance Level

South Africa is a resource-rich country. The locomotive industry, which provides the means to transport resources, is viewed as an important and growing industry. Improving the technology of a locomotive maintenance company, such as TRE, is vital to maintaining and extending the useful life of locomotives.

The following initiatives can help to enhance the level of maintenance at TRE, which is currently carrying out mainly an after-the-fact kind of maintenance. It is important to provide the necessary inspection steadily to improve efficiency.

1) Provide the Latest Maintenance Facilities and Technologies

- Provide maintenance facilities and technical guidance for the electric equipment of the latest electric locomotives
- Provide testing facilities and technical guidance to enhance the efficiency of maintenance operation
- Dispatch engineers to provide guidance in maintenance technology
- Invite TRE engineers and operators to Japan to receive education and training
- Provide support and guidance locally to help revise maintenance items

2) Provide Solutions to Various Issues related to Spare Parts

- Expand the methods of storing spare parts inside and outside of South Africa

TRE has been working with manufacturers to keep inventory of some of the spare parts that have long lead-time overseas or in South Africa. This method shall expand the overall level.

- Help research suppliers of alternative products and new suppliers

Support research to find alternative products and new suppliers for abolished parts or after the closure of factory

- Provide guidance in product management to enable long-term storage of electronic parts

3) Provide Technology for Analyzing Failures
- Supervise and support analysis to identify the causes of failures
- Supervise and support trouble-shooting
- Help obtain special testing equipment and manuals for investigating failures
- Supervise and support failure analysis using the abovementioned special testing equipment

4) Provide Support in Devising Mechanism to Pass on Maintenance Technologies
- Support the preparation of manuals to record the expertise and knowledge of veteran workers

Support the formation of a job appraisal system to give incentive to veteran workers to compile manuals documenting their expertise and knowledge by making them fully understand the merits of passing on the maintenance technologies to the young generation.

- Cooperate in the issuance of certificates by manufacturers

Manufacturers shall cooperate with TRE to issue certificates to TRE workers who have received certain education and training.

(2) Support Deterioration Investigation and Prevention Maintenance

TRE approaches maintenance after the fact, which is to repair the equipment after it fails.

The policy of TFR is to use locomotives for fifty years in an economic manner. In order to enhance the transport capacity of resources and general freight, the following assistance will be effective:

- For the electronic parts, it is effective to study the samples of items that have been identified as not having been sufficiently inspected on a regular basis
- Based on the research findings in Japan, it is effective to conduct deterioration study for electrolytic capacitor, printed circuit board, AVR, insulated amplifier, and optical parts.
- It is also necessary to consider alternatives of abolished parts. By identifying the symptoms of deterioration through deterioration study, it is possible to consider preventive maintenance such as by finding alternative parts at an early stage.

Since TRE does not have any experience in deterioration study, such studies can help it make preventive maintenance plans and use locomotives more efficiently by receiving support in preventive maintenance activities based on deterioration studies.

Chapter 5

Risk Factors

of the Railway Sector Investment Plan

Chapter 5　Risk Factors of the Railway Sector Investment Plan

As of the previous chapter, the Study Team confirmed that the railway sector in South Africa is continuously making huge investment in recent years. The Study Team also found that there are opportunities for Japanese companies to take part, depending on the field. However, the higher the risk for an investment plan to stall due to certain reasons, the more difficult it will be for Japanese companies to take part. Therefore, it is necessary to consider measures to reduce or hedge the risks.

Based on awareness of the above problem, this chapter will identify and analyze the various risk factors relating to the investment plans and businesses of the railway sector and review measures to reduce or hedge the risks.

Specifically, the Study Team reviewed and analyzed the risks from the following perspectives:

- Risk seen from the financial conditions of the national and provincial governments (5.1)
- Risk seen from the demand forecast of the PRASA and TRANSNET investment plans (5.2)
- Risk seen from the prospect of financing for PRASA and TRANSNET (5.3)
- Risk of project delay due to land acquisition and environmental regulations (5.4)
- Risk of delay seen from the decision-making mechanisms of the Department of Transport, Department of Public Enterprises, and provincial governments (5.5)

The national government and provincial governments are expecting economic ripple effect (including job creation effect) from the implementation of projects. For this reason, this Survey researched and analyzed the economic ripple effect of the investment plans for the railway sector and reviewed, based on the size of the effect, whether support from the central and provincial governments is adequate.

5.1 Financial Analysis and Investment Plans of the National and Provincial Governments（Risk seen from the financial conditions of the central and provincial governments）

In this section, the Study Team will analyze the risks from the viewpoint of the financial conditions of the national and provincial governments.

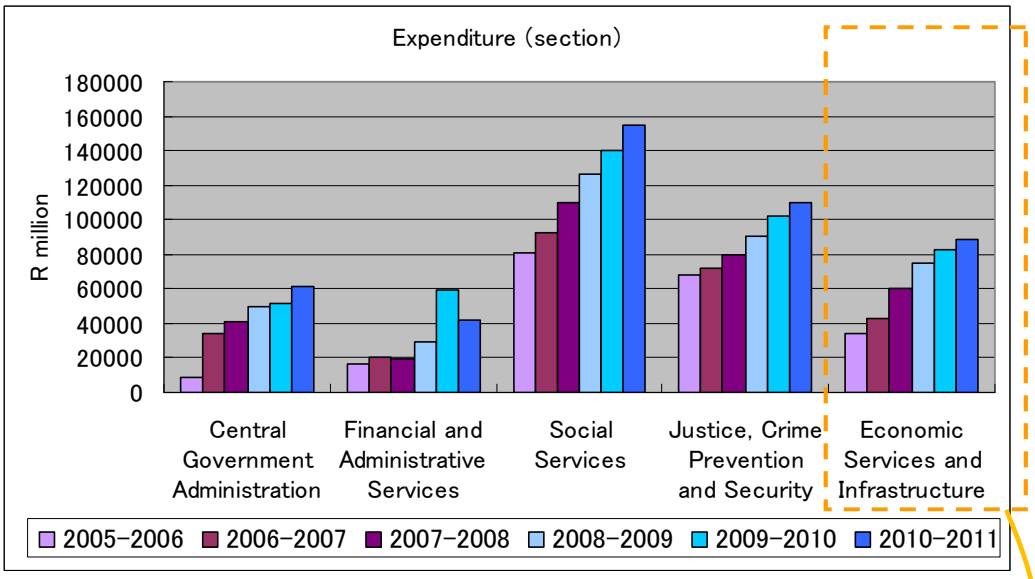
5.1.1 Analyzing the Financial Condition of the National and Provincial Governments

In this paragraph, the Study Team will examine the financial conditions of the national and provincial governments based on information published by government organizations and reports of international organizations and determine what effects the financial conditions of the national and provincial governments will have on the investment plans for the railway sector.

(1) Review of Financial Condition based on Information published by South African Government Organizations

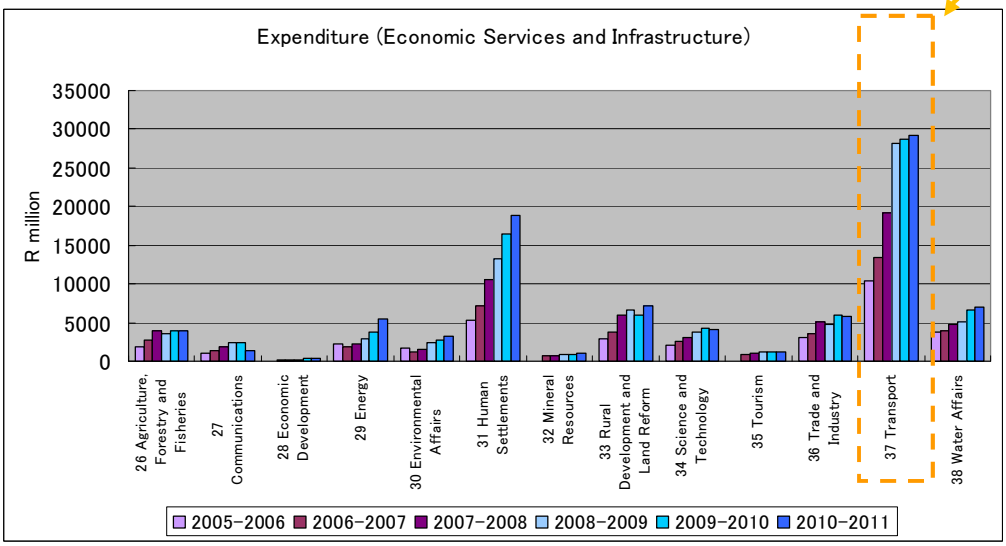
1) Financial Condition of National Government

According to information of the National Treasury (NT), revenue of the South African national government relies heavily on income tax/ corporation tax and value-added tax. On the other hand, “Social Services” (education and training, etc.) represents the largest percentage of expenditure, as shown in Figure 5-1. The budget for transport infrastructure moves steadily at slightly less than 30 billion ZAR per year, as shown in Figure 5-2. In the budget, road accounts for 30% and railway accounts for 30%, as shown in Figure 5-3.



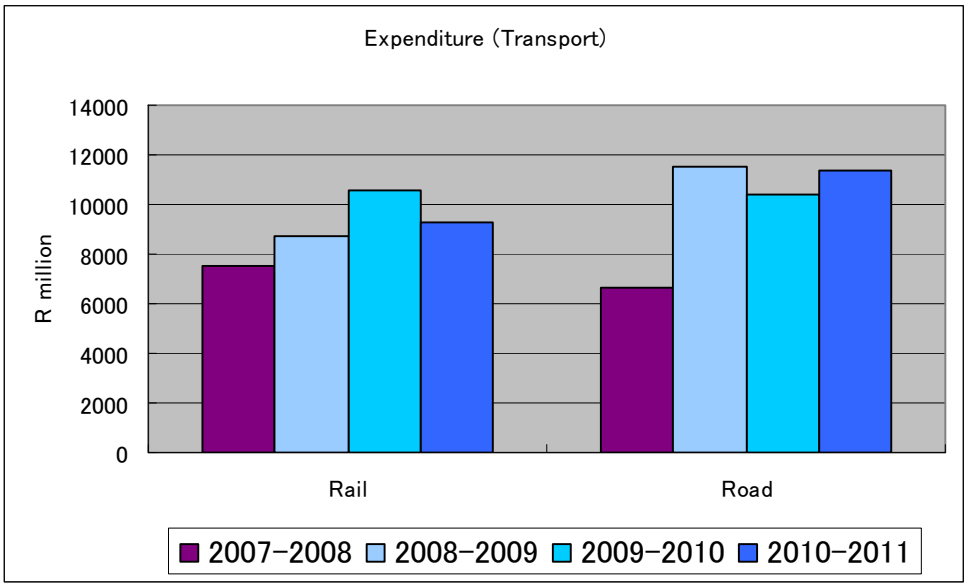
Source: Compiled by Study Team based on National Treasury "National Budget"

Figure 5-1 Changes in the Expenditure of National Government (1)



Source: Compiled by Study Team based on National Treasury "National Budget"

Figure 5-2 Changes in the Expenditure of National Government (2)



Source: Compiled by Study Team based on National Treasury "National Budget"

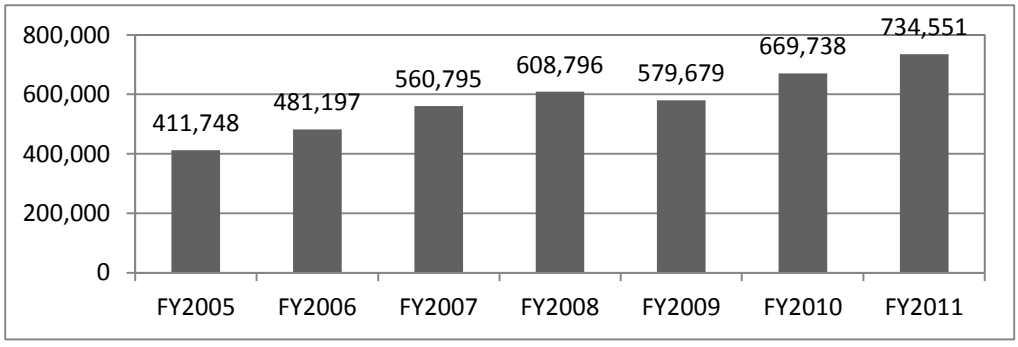
Figure 5-3 Changes in the Expenditure of National Government (3)

The risk factors seen from this financial condition are a) reduction in revenue due to economic effects and b) reduction in the percentage of allocation to the infrastructure sector from the total amount of revenue.

Regarding the former a), the income tax/corporation tax and value-added tax, which account for a great portion of the revenue, are all affected by the economic condition. Economic downturn can be a big risk factor. Besides the economic factor, increase and decrease in value-added tax due to political reason is also a risk factor.

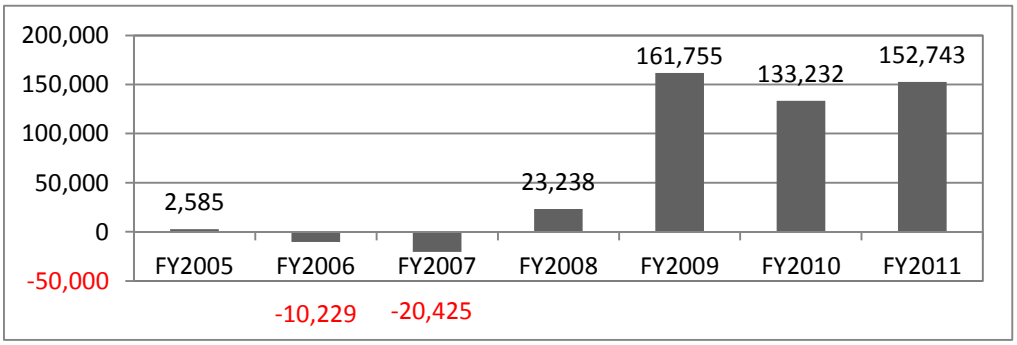
Looking at the actual revenue amounts of the national government, although revenue drops slightly in FY 2009, the last seven years demonstrate an upward trend. Impacts from the so-called "Lehman crisis" in FY 2008 and the European debt crisis of late are not so big. Revenue is believed to be growing steadily.

Looking at the debt condition (national debt, etc.) of South Africa, the debt amount has been on the rise since FY 2009. This is because the lower interest rate in government bond has reduced the cost of borrowing, making it easier to procure funds from the market.



Source: Compiled by Study Team based on National Treasury "National Budget"

Figure 5-4 Changes in the Revenue of National Government (unit: million ZAR)



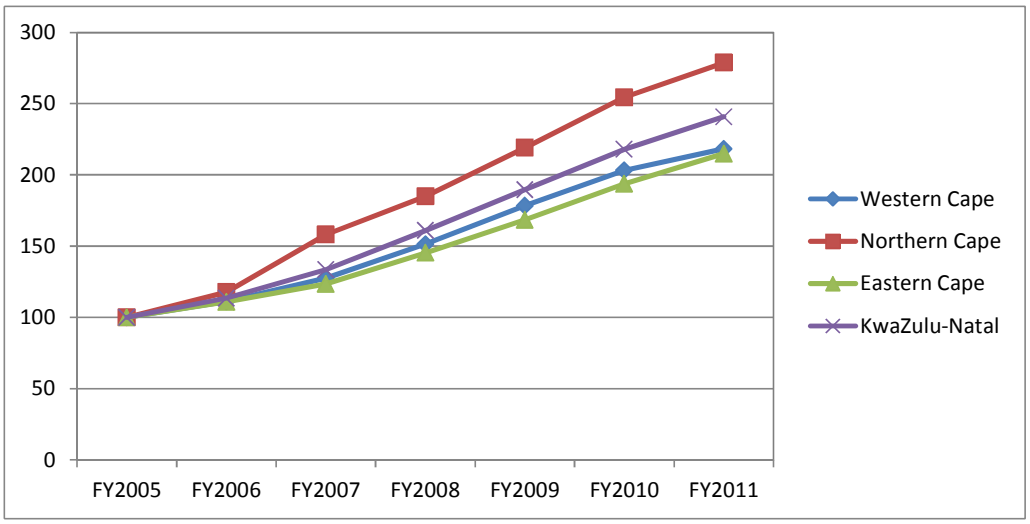
Source: Compiled by Study Team based on National Treasury "National Budget"

Figure 1-5 Debt (Net) Condition of the National Government

Regarding the latter b), there is no credible assurance that NT will continue to give grant money to the infrastructure sector in the mid-term. However, it is also quite unlikely that the national government will cut infrastructure expenditure in the short term[1] because of the huge demand for infrastructure at this time, the anticipated economic ripple effect from infrastructure investment, including job creation, and the resulting effect of lower unemployment rate.

2) Financial Condition of Provincial Governments

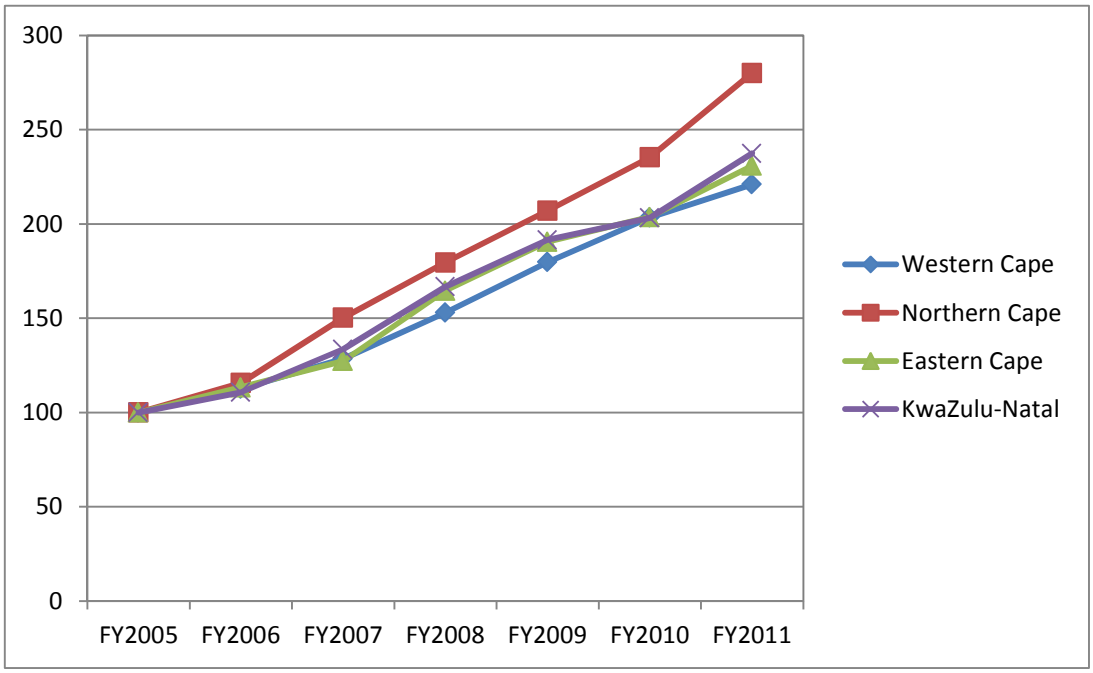
The Study Team verified the total revenue, total expenditure, and infrastructure-related expenditure of the various provincial governments, all of them show a rising trend in the last seven years. Impacts of the "Lehman crisis" and the European debt crisis of late are believed to be limited. However, because a great portion of the provincial governments' revenue is dependent on grant money from the national government, it can be affected easily by the financial condition of the national government.



Source: Compiled by Study Team based on National Treasury "National Budget"

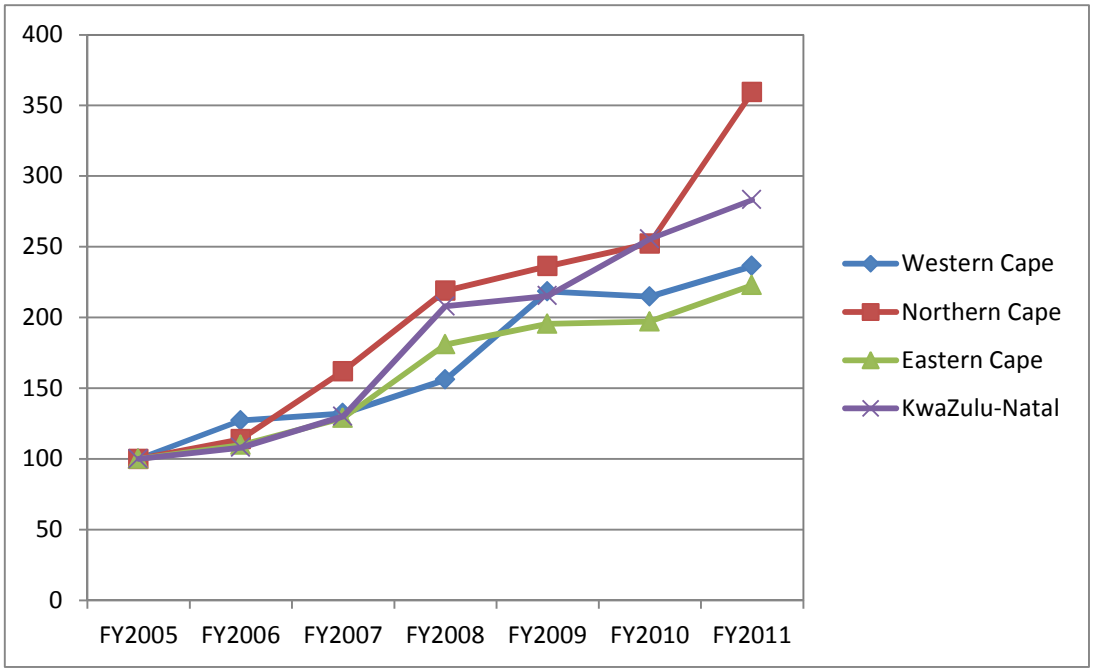
Figure 5-6 Changes in Total Revenue of Provincial Governments
(Trend using the FY 2005 values of the provinces as 100)

[1] Observation from interview of the NT PPP Unit



Source: Compiled by Study Team based on National Treasury "National Budget"

Figure 5-7 Changes in the Expenditure of Provincial Governments (Trend using the FY 2005 values of the provinces as 100)



Source: Compiled by Study Team based on National Treasury "National Budget"

Figure 5-8 Changes in the Transport/ Infrastructure-related Expenditure of Provincial Governments (Trend using the FY 2005 values of the provinces as 100)

(2) Review of Financial Analyses by International Organizations

When the Study Team reviewed the financial analyses conducted by international organizations, the Study Team learned that the economic growth of South Africa would continue to be strong in general, as shown in Table 5-1. However, if the European debt crisis of late deepens, there is

the opinion that the impact on South Africa will be limited and the opinion that there will be risk of drastic economic downturn caused by a sudden drop in the rand currency, rise in import price, and so on. It is necessary to pay attention to the development from now on.

Table 5-1 Review of the Financial Condition of South Africa by International Organizations

Name of document	Comment
IMF(2012) [World Economic Outlook]	・ Effects of the worldwide economic downturn on sub-Saharan Africa are limited. ・ The GDP growth rates in the next two years are projected to be over 3%.
JBIC (2011) “Positive growth in six consecutive quarters and future economic forecast “South Africa”	・ According to IMF, although the economic growth rates of South Africa are projected to be 3.5% in 2011, 3.8% in 2012, and 4.0% from 2013 onward, the growth rates are expected to be lower than its neighboring countries south of the Sahara. ・ In particular, the export increase rate for 2011 is expected to drop to 1.6%, thus putting constraint on the economic growth of South Africa.
OECD(2012) “OECD Economic Outlook” p.188	・ External risks include worsening European debt crisis, which will hamper the export demand of South Africa, and the further rise in oil price, which will dampen the growth of domestic demand. ・ Internal risks include suppressed investment from family budget in the backdrop of a slump in housing price, and limited electricity supply
African Development Bank (2012) “South Africa's Quest for Inclusive Development” p. 20	・ The government announced adoption of the New Growth Path (NGP). NGP focuses on the areas that have high potential for creating jobs, such as infrastructure, agriculture, mining, industry, tourism, etc. It plans to create at least half a million jobs every year in the next 10 years. ・ However, there are concerns about the lack of industrial policies, reform of the labor market, and strategies for promoting the export of resources in order to increase the competitiveness of South Africa amid a high unemployment rate and the global economy.
Itochu Economic Research Institute (2012) “Economic Monitor: Economic Slowdown of South African Economy Deepening”	・ The South African economy is slowing down. Besides sluggish export growth from the effects of the European debt crisis, the BEE Act has come full circle in job creation. It is even putting a damper on the rise in consumer spending. Such growth constraints will remain for some time to come. ・ The growth rates for the immediate future are expected to be below the average 3% for 2010–2011. Furthermore, in addition to the weak financial structure of the current account deficit, the monetary authority of South Africa is not adequately prepared to deal with the risk of capital flight. For this reason, if the European debt crisis deteriorates in the near future, there is the risk that the economy will go into a drastic downward spin because of a plummeting rand and rising import prices.

World Bank (2012) "South Africa Economic Update Focus on Inequality of Opportunity"	・The largest downside risk of the South African economy is the European debt crisis. Europe is South Africa's largest export market. The correlation between the two economies is strong. ・This risk is of a highly uncertain nature and is difficult to predict.
World Bank (2012) "South Africa Economic Update Focus on Savings Investment, and Inclusive Growth"	・In terms of the major risks of the South African economy, the risks from countries outside of South Africa include Europe's economic crisis, oil price, increased market volatility caused by the influx of opportunistic capital, and so on. ・Domestic risks include a weak environment for business operation, high debt burden on the family budget, and so on.

Source: Compiled by Study Team

(1) Variables in the Finances of the National and Provincial Governments Related to the Railway Sector

PRASA is receiving grant money from the government and TRANSNET is raising funds with government's debt guarantee. There is a possibility that these subsidies and guarantee may be reduced in the future[2] for the following reasons:

- The payment system of grant money may change. Specifically, under the current system, the grant money for passengers is given by NT to PRASA via DOT. It is then used for PRASA operations in various areas. In relation to this, the grant money is likely to shift to local areas in accordance with the National Land Transport Act. Thus, the grant money that used to be given to PRASA for railway development may now increase allocation to transport infrastructure other than the railway in order to realize a comprehensive transport system.
- Due to the comment about a lack of transparency in the appropriation method of grant money, NATMAP stipulates that NT will allocate funds to a third-party organization, which will then give the funds to PRASA.

Given that the abovementioned grant money and debt guarantee from the government to PRASA and TRANSNET may fall and that the fund appropriation method may change, it becomes more important for PRASA and TRANSNET to have their own revenue as fund sources for the investment plans. This means that the future demand forecast will become extremely important to PRASA and TRANSNET. The future demand forecast will be discussed later.

[2] Based on interview of the NT PPP Unit

5.1.2 Investment Plans of the National and Provincial Governments

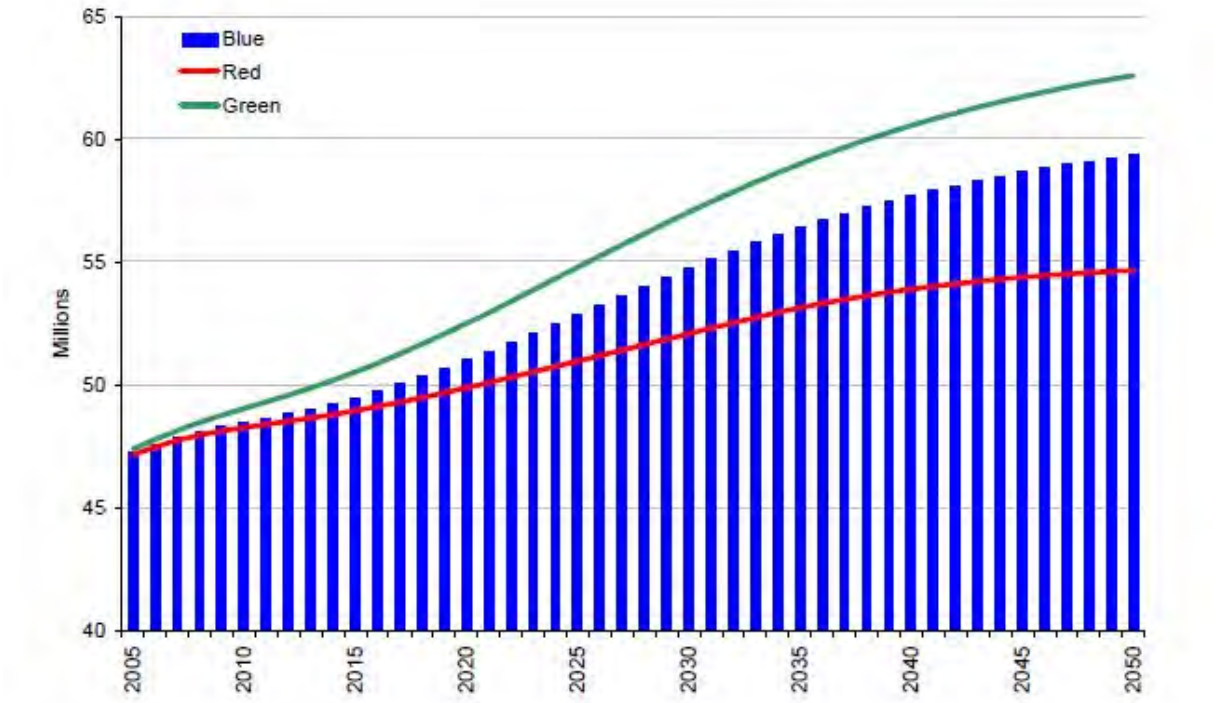
(1) Investment Plans of the National and Provincial Governments for the Railway Sector

1) Investment Plan of National Government

Chapter 3 summarizes the contents of NATMAP drawn up by the national government. Here, the Study Team will review the demand forecast method and results, which are the premises of NATMAP, to determine the estimated risks.

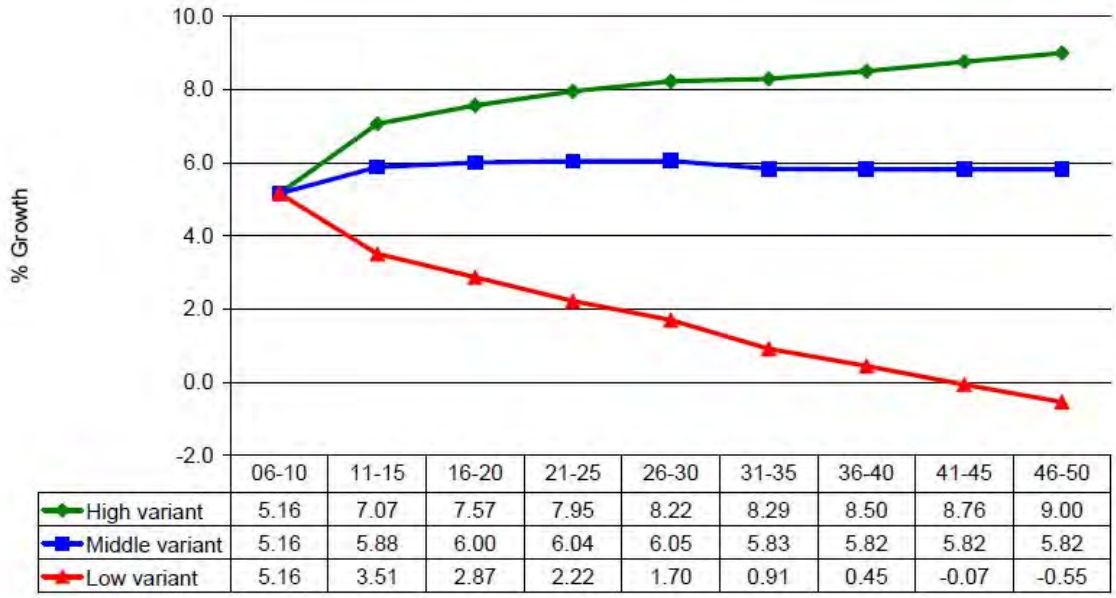
The demand forecast, which serves as the basis of NATMAP, was performed using the "4-step method," which is also frequently used in forecasting railway demand in Japan. The "4-step method" in NATMAP is not specialized in terms of modeling. The actual results of road freight and airfreight are used for the demand forecast. The National Home Travel Survey (NHTS) conducted in 2003 is used for the passenger data. The actual data of freight handled by railways/ports/pipelines collected by mainly TRANSNET are used for the freight data.

Changes in population and economic growth in the future, which are the premises of NATMAP, are shown below. In an average scenario, the population is expected to increase approximately 30% from 2005 to 2050. In addition, in an average scenario, the economy is anticipated to grow at an annual rate of around 6% by 2050. The possibility of negative growth in 2050 in a low growth scenario is taken into account.



Source: DOT information material

Figure 5-9 Projected Numbers of Future Population as the Premises of Demand Forecast in NATMAP



	06-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50
High variant	5.16	7.07	7.57	7.95	8.22	8.29	8.50	8.76	9.00
Middle variant	5.16	5.88	6.00	6.04	6.05	5.83	5.82	5.82	5.82
Low variant	5.16	3.51	2.87	2.22	1.70	0.91	0.45	-0.07	-0.55

Source: DOT information material

Figure 5-10 Future Economic Growth Rates as the Premises of Demand Forecast in NATMAP

2) Investment Plans of Provincial Governments

Similar to the national government, the provincial governments are also formulating transport-related investment plans. Information related to the demand forecast of railway and transport of the various provinces is summarized below. Few cases show clear premises for the future population and economic growth rates. Some even project an economic growth rate over 7% for South Africa as a whole.

Table 5-2 Overview of the Investment Plans of Provincial Governments

Name of province	Development plans/economies of various provinces
Western Cape province	・The province formulated the “Western Cape Provincial Spatial Development Framework (PSDF)” as the development plan. Its Department of Transport and Public Works formulated the “Provincial Land Transport Framework 2011/12-2015/16” as the transport plan. ・The development plan places emphasis on investment in roads and railways to link the urban centers of Cape Town and Gauteng. ・The development plan is promoted in the backdrop of a shortage in water resources, climate change, air pollution, traffic jam, few opportunities for small and medium-sized companies to succeed, and low quality of education. ・The transport plan puts great emphasis on the development of urban railways. On the other hand, the shortage of funds for developing the urban railway has been pointed out. ・In the formulation of the transport plan, the population and economic forecasts of NATMAP are used as the basis for reviewing future demand.

Northern Cape province	・The “Northern-Cape Provincial Growth and Development Strategy (NCPGDS) 2011” is formulated as the province’s development plan. ・Population growth is considered a social issue for the province in the future. ・Mining is an important industry in the province. Transport-related infrastructure development is important for the growth of the mining industry.
Eastern Cape province	・The “Provincial Growth and Development Plan (PGDP) 2004-2014” is the province’s development plan. There is also the transport plan “Strategic Plan for the Fiscal Years 2010/11-2014/15.” ・The development plan is premised on maintaining the economic growth rate at 5–8% until 2014. ・The transport plan raised the issue that railway has not been fully utilized. However, there is no mentioning of population forecast, which is the premise of the transport plan.
Free State province	・The “Draft Provincial Growth and Development Strategy Free State Vision 2030” has been formulated as the province’s development plan. ・Due to the geographical characteristic of the province’s central position in South Africa, investment in transportation and logistics is one of the pillars of the development plan. The plan aims to achieve an annual economic growth rate of 7% by 2030.
Limpopo province	・The “Limpopo Employment, Growth and Development Plan 2009–2014” has been formulated as the province’s development plan and the “Strategic Plan for 2010/11–2014/15” its transportation plan. ・The development of railway is an important topic in the province’s development plan. The plan mentions both the upgrade of existing lines and construction of new lines. ・The transportation plan mentioned the need to develop railway as a way to prevent the severe deterioration of roads due to freight transport by trucks.
Gauteng province	・The “DRAFT Gauteng Vision 2055:The Future Starts Here” is formulated as the development plan and the “Gauteng Land Transport Framework 2009–2014” is formulated as the transportation plan. ・The development plan mentions expansion of the public transport network, including the railway. ・The plan uses “Stat SA” as the basis of future population, which serves as the premise of the development plan. The plan is thought to be premised on an annual economic growth rate of within 4% by 2014. ・The forecast of freight demand by TRANSNET is used for the transport plan. ・Looking at the investment amounts for roads and railways shown in the transport plan, the Study Team found that the investment amount for the railway is much higher. This indicates the high expectation for railway development.
KwaZulu Natal province	・The “Five-year Strategic Plan 2009/2013’ is formulated as the province’s development plan and the “Revised Strategic Plan 2010/11-2014/15” is formulated as the transportation plan. ・The development plan focuses on trade and logistics It also places emphasis on the development of infrastructure to support trade and distribution. ・The transportation plan emphasizes improvement of the bus sector. It also points out the importance of railway as a means to reduce environmental burden.

North West province	・The “North West Provincial Growth and Development Strategy 2004–2014” is formulated as the province’s development plan and the “Strategic Plan For the fiscal years 2010–2014” its transportation plan. ・The development plan states that infrastructure development is a pillar of the development plan. It also plans to achieve the target of an annual economic growth rate of 6.6% by 2014. ・The transportation plan does not have too many railway-related comments. The province sees great importance in road development in general.
Mpumalanga province	・The “Mpumalanga Economic Growth & Development Path” is formulated as a development plan. ・The development plan points out the development of new railways and revitalization of rail freight as important items. ・The setting of future population and future economic growth rates, which are the premises of the development plan, is not mentioned in particular. ・The development plan mentions the importance of measures to tackle poverty.

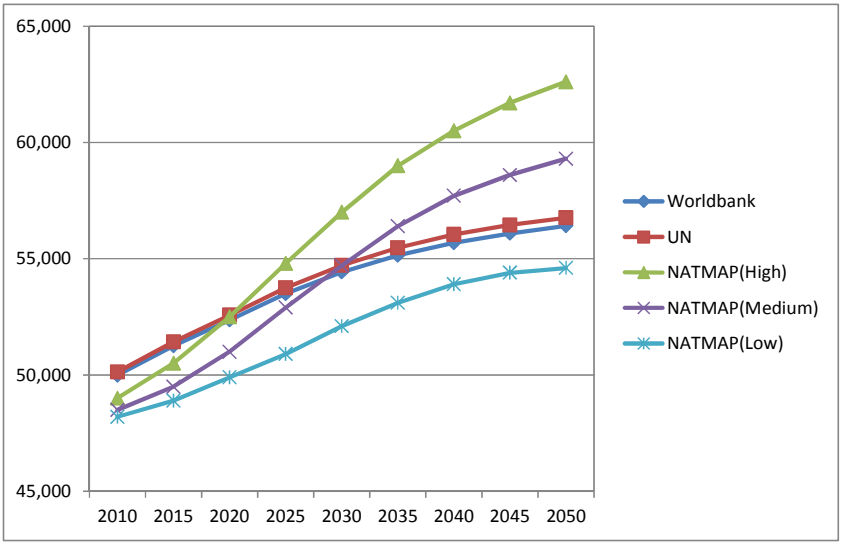
Source: Compiled by Study Team

3) Validity of the Plans of the National and Provincial Governments

As mentioned above, the various provincial governments did not clarify the future population and economic growth rates when formulating railway-related investment plans, such as development plans and transportation plans. On the other hand, NATMAP seems to assume that the annual economic growth rate will continue at about 6% in an average scenario. Reports prepared by international organizations show that the economic growth rate of late is about 4%. It is necessary to continue to pay attention whether the economic growth rate can continue to be around 6%, especially in the long term.

Figure 5-11 shows the projected numbers of future population in NATMAP and those published by the World Bank and the United Nations. The projected population number in the NATMAP average scenario is lower than the projected levels by the World Bank and the United Nations up until 2025. However, the projected numbers in the NATMAP average scenario become higher from 2030 onward.

No matter whether it is the economic growth rate or the projected population, it is always necessary to consider their viability from a long-term perspective.



Source: Compiled by Study Team based on various statistics

Figure 5-11 Comparison of Future Population Numbers of South Africa

(2) Implementation Status of PPP and Feasibility of Its Application to the Railway Sector

Gautrain in Gauteng province is the only railway project implemented using public-private partnership (PPP). PPP scheme per se has been established as a system in South Africa, so there should not be too many system-related issues. Therefore, as long as a project is bankable, it can be implemented. In reality, however, a large sum of grant money (ridership guarantee) has been given to Gautrain every year. Thus, it leaves room to examine whether PPP has been properly implemented since it is designed originally to allocate risk. From the viewpoints of other provincial governments, Gautrain is a special case that has received tremendous support from the national government. Some believe that PPP is hard to sell at this time.

Furthermore, the PPP scheme has mainly been used for hospitals and few for railway projects. The reason is that PRASA has been receiving large sums of grant money from the national government and provincial governments so it has enough resources to undertake projects on its own. On the other hand, TRANSNET has enough capability to procure funds on its own. For this reason, there is very little chance for PRASA and TRANSNET to use PPP to finance projects at this time. However, as explained earlier, if the grant money to PRASA declines in the future, then the importance and necessity of PPP scheme will rise.

It has been pointed out that besides the above, the artificially set low train fare and shortage of human resources on the government side pose serious problems.

(3) Variable Elements in the Investment Plans

The demand for infrastructure is extremely high. No element is likely to reduce the demand for infrastructure in the short term. However, since the decision for many projects are political, the order of the projects may change based on the political condition. Depending on the area, a project runs the risk of being delayed.

5.2 Investment Plans if Railway Modernization Policy is Adopted (Risk seen from demand forecast in the PRASA and TRANSNET investment plans)

In this section, the Study Team will analyze the risk seen from demand forecast in the PRASA and TRANSNET investment plans.

5.2.1 Concept of Demand in PRASA Investment Plan

Chapter 3 summarizes the contents of the PRASA investment plan. Here the Study Team will review the demand forecast method and results, which are the premise of the plan, to determine the estimated risks.

The demand forecast reviewed here was implemented by PRASA during the decision-making process of its rolling stock procurement program, which will be explained later. It was supervised by a joint steering committee of presiding departments, including NT, DOT, DPE, and DTI. Contents of the demand forecast have been approved.

In this demand forecast, three scenarios, namely, “low,” “medium,” and “high” were used to perform forecast. In the end, the “high” scenario was adopted for the long-term forecast.

For the “low” scenario, the number of Metrorail passengers in the last 20 years as the explained variable, and the population and GDP as explanatory variables in a regression analysis to estimate the base line are used. In addition, new rolling stock, service improvement, and other standards to forecast the “medium” and “high” scenarios are used.

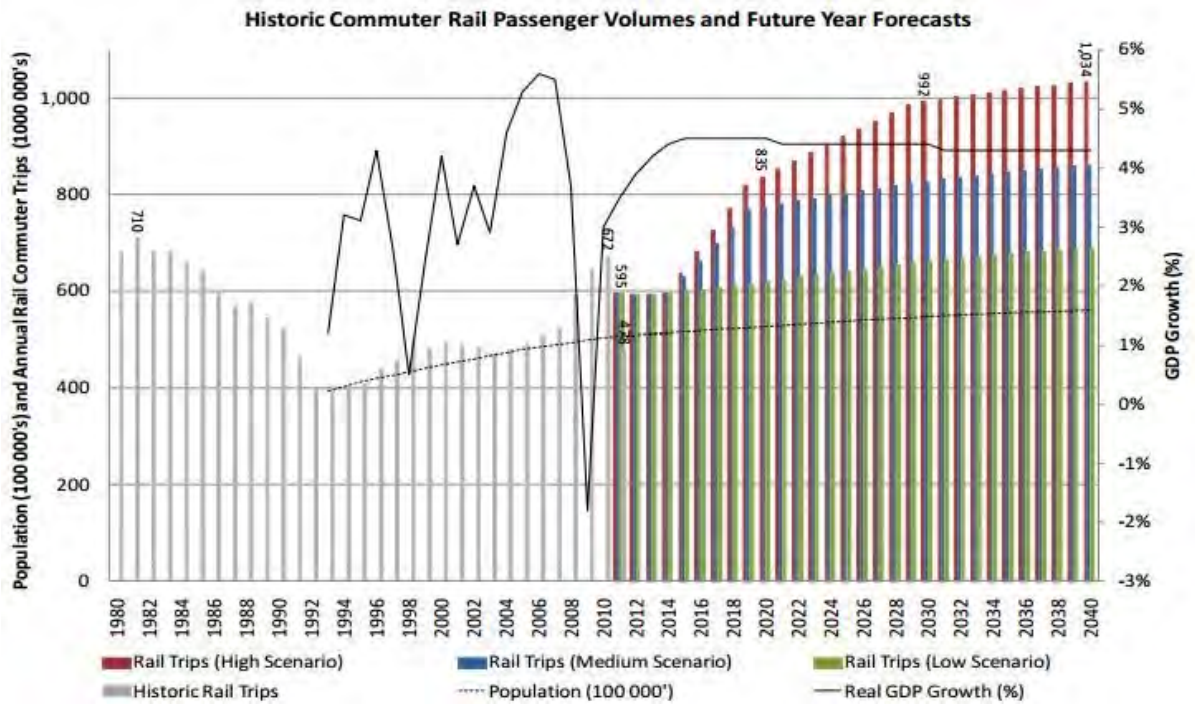
Passenger railway in South Africa is a transportation means for low-income people who do not own any cars or have any other transportation means. If the railway does not take any particular measures and if the Study Team does not anticipate any big changes to the percentages of population with different income levels in South Africa, the method using population and GDP

as explanatory variables can be justified to a certain extent as the “low” scenario, assuming a safe case of having no modal shift from other transportation means. The projected result of a low case reflects only growth from population and GDP growth. It does not show drastic growth. The future GDP growth rate is projected to be over 4%. According to the future prospect summarized in 5.1, the projection might be too optimistic.

On the other hand, the projected results of the medium and high scenarios, which take into consideration new rolling stock and service improvement, show dramatic increase. Specifically, assuming a 0.8 value of elasticity versus a 30% increase in service in 2015 thanks to the introduction of new rolling stock and improved service, a 25% increase in railway passenger in 2015 is anticipated. On the other hand, in the high scenario, the number of railway passengers will increase another 20% because of the improved railway service and the anticipated effect of people being drawn to the station vicinity. This assumption of people gathering around station is based on an international study of Transit Oriented Development (TOD), which indicates that railway users will increase 23% with higher intensity of land use within a radius of 500 meters from the station.

It is necessary to pay attention because it is easy to overestimate the increased demand from improved service and the effect of change in land use in the case of urban railway. The feasibility study report indicated that the long-term portion of the forecast was easily conducted in its demand forecast and that a detailed feasibility study would be conducted in the future. The bid in 2012 was for the Phase I investment of approximately 3,600 units. It is desirable to conduct a detailed feasibility study for Phase II, which is the remaining half of the investment, as stated in the feasibility report.

For public projects in Japan, including railway projects, concerned entities conduct a “reassessment” five years after the start of construction to review the demand forecast and an “ex-post evaluation” to verify the conditions generating the effects five years after the start of service in order to review measures to enhance the effects. Since the “medium” and “high” scenarios of South Africa anticipate drastic increases in the number of passengers, it is necessary to continue to monitor if the number of users has actually increased after the improvement of services and if the public transport-based urban development has made progress so that investment plans can be revised and measures can be taken to promote use.



Source: PRASA "Feasibility Study: Detailed feasibility study for the procurement, financing and maintenance of rolling stock for the Metrorail services," 12 July 2011

Figure 5-12 PRASA Demand Forecast Results

5.2.2 The Concept of Demand in the TRANSNET Investment Plan

Chapter 3 summarized contents of the TRANSNET investment plan. Here the Study Team will review the demand forecast method and results, which are the premise of the plan, to determine the estimated risks.

TRANSNET used the Freight Demand Model (FDM), transportation model, and market model.

FDM is a model that projects the total freight demand of South Africa. Based on the results, the freight traffic volume between areas in South Africa using the transportation model is projected. Furthermore, the market model to project the transport volume, such as railway, by transport mode is used. These are usually based on the 4-step method.

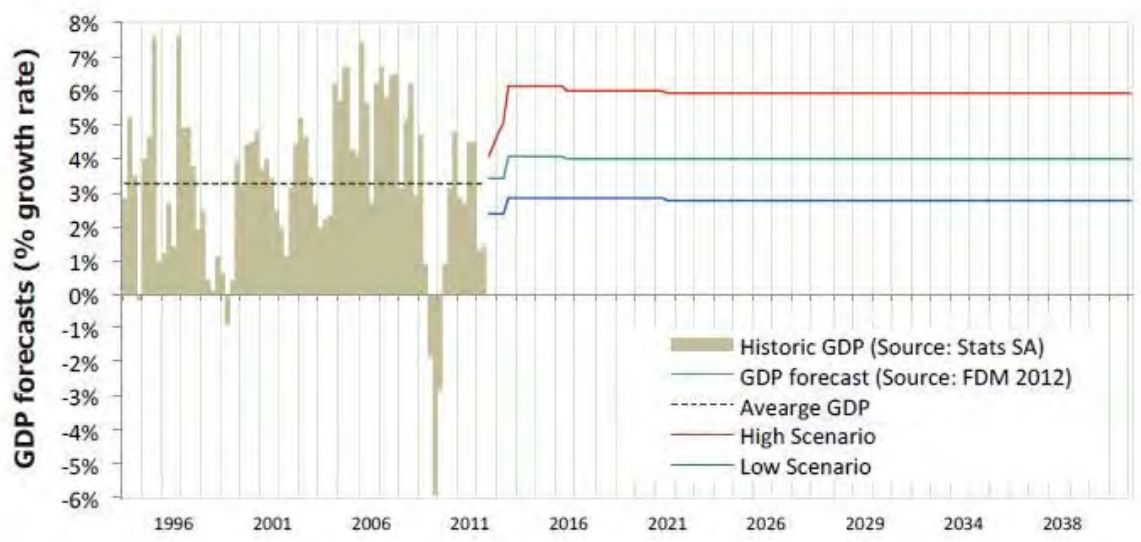
(1) FDM (Freight Demand Model)

FDM uses the following factors to project the freight transport volume. In particular, based on a past analysis that found a strong relationship between GDP growth rate and freight transport volume, a trial calculation using FDM is implemented. However, since it was not thought that the demand for mineral resources would increase in proportion to economic growth, a forecast taking into consideration other elements besides the GDP growth rate is conducted.

- International economic outlook
- GDP growth and inflation
- Projected growth of industry sectors
- Government capital spending
- Population growth
- Various other forecasting factors

Based on the trial calculation of GDP growth rate by the companies Conningarth and Quantec, the GDP growth rate is set at approximately 4%. The forecast of population growth is quite accurate

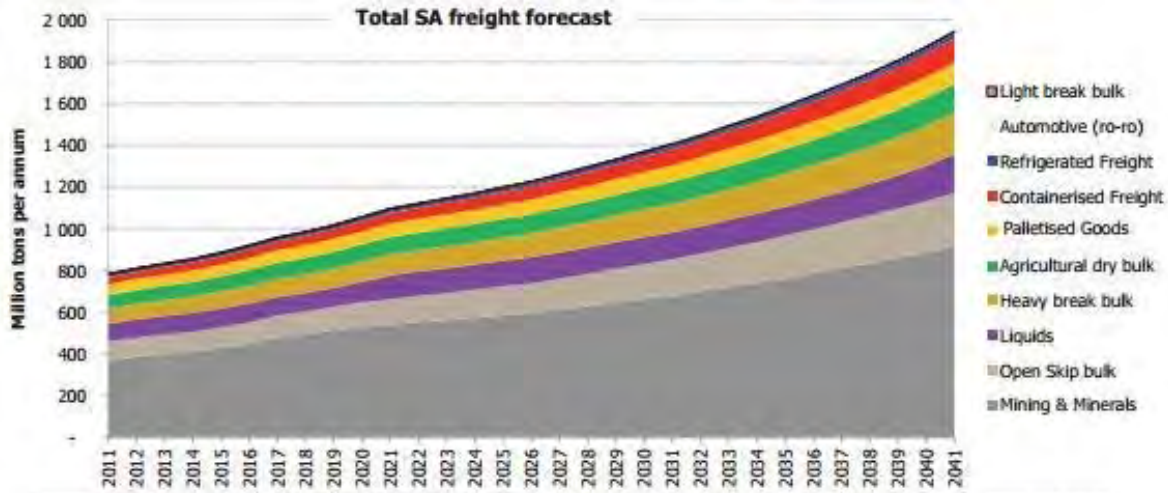
in general. However, it is difficult to forecast international economic outlook and GDP growth rate due to their big fluctuations. Therefore, various scenarios to perform demand forecast are used.



Source: TRANSNET "Long Term Planning Framework 2012," 2012

Figure 5-13 Forecast of GDP Growth Rate

Looking at the forecasted result of future freight demand using FDM, depending on the item, the average growth rate of transport volume from 2011 to 2041 is in the range of 3.1–3.5%. According to the economic outlook of late, this is not an extremely high increase. However, it is necessary to pay attention if South Africa can continue to grow at over 3% for the long period over 30 years.



	2011	2016	2021	2026	2031	2036	2041
Surface	762	885	1 043	1 188	1 373	1 608	1 927
Rail suitable	356	420	494	561	641	745	885
Planned rail	212	308	393	456	536	611	689
General freight	73	134	178	241	312	370	437

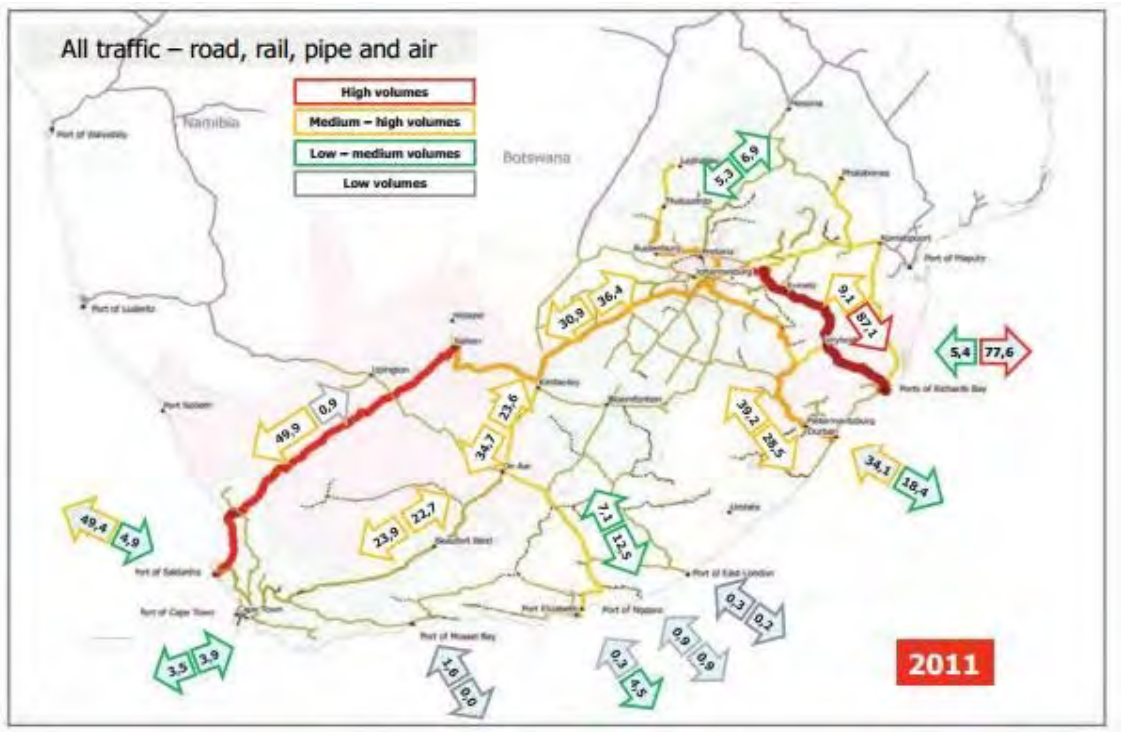
(Unit: million tons)

Source: TRANSNET "Long Term Planning Framework 2012," 2012

Figure 5-14 TRANSNET Demand Forecast Results from FDM

(2) Transportation Model

The transportation model is a model used to forecast the distribution of overall freight demand volume by route based on FDM.



Source: TRANSNET "Long Term Planning Framework 2012," 2012

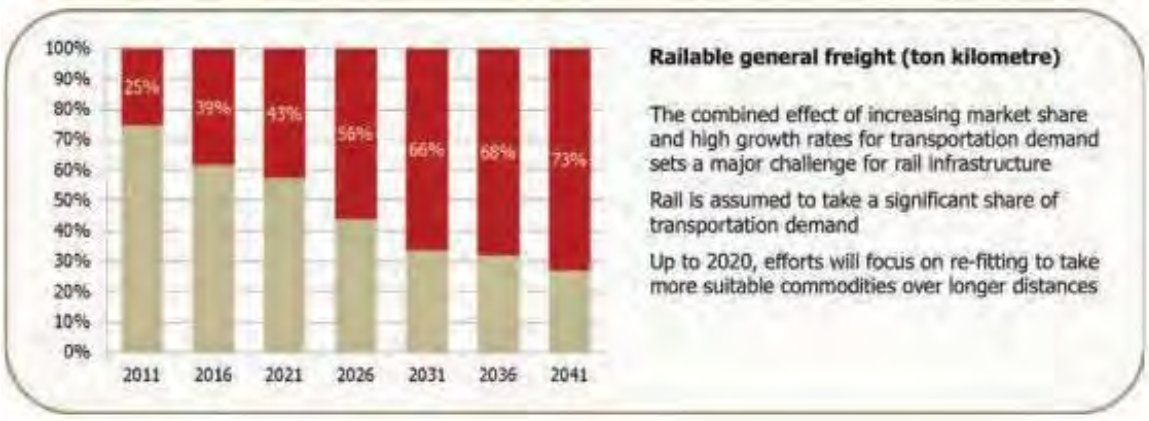
Figure 5-15 TRANSNET Demand Forecast Result using Transportation Model

(3) Market Share Model

Market Share Model estimates the shares of transportation modes (mainly between railway and road). The factors that are considered for the estimation are transport distance for each product, size of the transport product, quality of the transport route, etc.

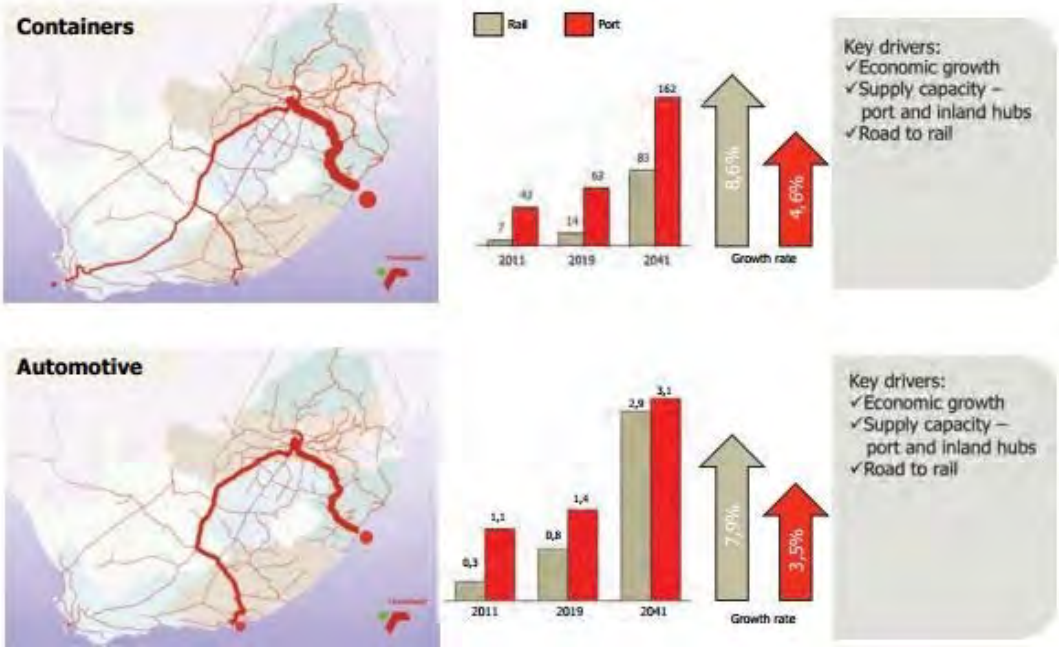
South Africa's market share model are characterized by projections that the share of rail freight will reach 73% by 2041, the competitive edge of rail freight with OD distance over 300 km will improve, and so on.

The time and cost of loading at port terminals also have a tremendous effect on the shift of freight from truck to rail. As shown in figures 5-16 and 5-17, in order for the following results forecasted by TRANSNET to become a reality, it is necessary not only to invest in railway but also to ensure that investment in terminals goes smoothly, as envisioned in NATMAP. Whether or not such comprehensive investment can move forward smoothly is a risk factor.



Source: TRANSNET "Long Term Planning Framework 2012," 2012

Figure 5-16 TRANSNET Demand Forecast Result using Market Share Model (1)



Source: TRANSNET "Long Term Planning Framework 2012," 2012

Figure 5-17 TRANSNET Demand Forecast Result using Market Share Model (2)

5.3 Financing Prospect

The Study Team summarizes the risks viewed from the prospect of financing of the national government, provincial governments, PRASA, TRANSNET, etc.

5.3.1 Prospect of Financing for the Public Sector

(1) National Government

The national government strongly recognizes the need for infrastructure development. It does not have much resistance against it. At the national government level, rather than financing, the protracted deliberation of projects is becoming a problem.

(2) Provincial Governments

At the provincial and city levels, procuring funds for the implementation of railway projects is not necessarily going smoothly. Therefore, the need for procuring funds using the PPP approach may rise. In the example of Gautrain, Gauteng province made large-scale capital contribution to a special purpose vehicle (SPV).

(3) Public Corporations

1) PRASA

Currently about 70% is grant money from the national government and the remaining 30% is fare revenue. As explained in 5.1, the allocation and issuance methods of grant money may change in the future. Furthermore, as explained in 5.2, the fare revenue is expected to increase as improved service will increase the number of users. It is necessary to pay attention to the viability of such assumption.

PRASA plans to get rid of the grant money that it receives from the government. Income from real estate investment will provide 60% and fare will provide the remaining 40% revenue.

On the other hand, the feasibility study (proposal) for the Rolling Stock Fleet Renewal Project reviewed in 2011 has also considered raising the necessary capital for future investment projects from the financial market. However, in view of the project approach and other reasons, PRASA seems to think that it is better to raise funds for projects based on government grant and its business revenue.

2) TRANSNET

The financial performance of TRANSNET in FY 2012 shows that its revenue is 45.9 billion ZAR, profit for the year is 4.1 billion ZAR, the return on average total assets (ROA) (excluding CWIP) is 6.8%, and the capital and reserves is 79.4 billion ZAR. In addition to such excellent financial performance, TRANSNET has an advantage in raising funds; it can use the government-backed bond. At present, it is raising funds from both the capital market and bond market (local bond, international bond). It is not raising funds from the Development Bank of South Africa (DBSA) or the government. This is because TRANSNET can procure funds at better interest rates from the capital market than from DBSA through the issuance of company bonds with government guarantee. It is not necessary for it to borrow money from DBSA. (The interest rate at DBSA is 0.75% higher than the average 12% in South Africa. Since there is no request from TRANSNET, DBSA is not providing funds for railway projects in South Africa. Furthermore, the loan period for DBSA is 15 years, which is shorter than the 20 years required for conventional railway projects.)

Two-third of the 300 billion ZAR of the TRANSNET investment plan will be from sales revenue and one-third will be raised from the capital markets. As explained in 5.2 Sales Revenue, it is necessary to pay attention to the assumption that investment in railways and their connecting terminals will go smoothly and that modal shift from truck to rail will be successful.

Raising funds from the capital markets requires approval from the National Treasury; specifically, a corporate plan shall be submitted to the Minister of DPE and NT.

5.3.2 Prospect of Financing in the Private Sector

(1) Special Purpose Vehicle (PPP Scheme)

DBSA and commercial banks are extremely earnest in investment and loans. If the project is good, the possibility of the project not going forward because of a lack of funds from the lenders is very low. However, projects in South Africa are basically financed in rand. The environment is still very difficult for procuring dollar- or Euro-denominated funds from overseas investors. The condition in South Africa at this time does not require active financing

for railway projects by overseas investors. However, when it becomes necessary to seek financing from overseas investors in the future to promote railway projects, it is possible that railway projects may be deterred due to insufficient fund supply from overseas investors.

(2) Small and Medium-sized Businesses

In South Africa, government schemes to assist small and medium-sized businesses in railway-related industries to procure funds are established to a certain extent. Mainly, DTI supervises the assistance schemes. The schemes that are likely to be used by small and medium-sized businesses in railway-related industries are shown below. Most of these schemes offer free of tax incentive after the projects have been implemented. For this reason, it may be difficult for businesses low in capital to make investment because of the appeal of the incentive. Although certain issues exist, the environment to facilitate the financing of small and medium-sized businesses is in place to a certain extent.

1) 12I Tax Incentive (12I)
- Assistance programs for green fields and brown fields. Support capital investment, and education and training through tax
- 35% tax exemption for investment. Maximum of 550 million ZAR for a green field project and a maximum of 350 million ZAR for a brown field project
- Four years of tax exemption for education and training expenses: 36,000 ZAR per employee and 20 million ZAR per business

2) Manufacturing Investment Programme (MIP)
- Aims to revitalize the manufacturing industry, create jobs, and seek sustainable business growth
- Offers grant to cover 15–30% of the investment amount for a new project or expansion. The targets are machinery, devices, factories, commercial vehicles, and land/buildings.
- 30% grant for businesses with investment amount below 5 million ZAR
- 15–30% grant for businesses with investment of 5–30 million ZAR (maximum 200 million ZAR)
- 15% grant for businesses with investment over 30 million ZAR (maximum 200 million ZAR)

3) Manufacturing Competitiveness Enhancement Programme (MCEP)
- Aims to upgrade production facilities, processes, etc. and improve the skills of employees
- Offers a 2-year tax-free grant equivalent to a certain percentage of the value added
- A grant equivalent to 7% of the value added, offered to businesses with assets over 200 million ZAR
- A grant equivalent to 10% of the value added, offered to businesses with assets at 30–200 million ZAR
- A grant equivalent to 12% of the value added, offered to businesses with assets at 5–30 million ZAR
- A grant equivalent to 15% of the value added, offered to businesses owned 100% by black people or with assets below 5 million ZAR
- The budget for 2012 is 1.2 billion ZAR. It is likely that the amount will not be fully consumed. A total of 5.2 billion ZAR has been budgeted for 3 years.

5.3.3 Concept of Infrastructure Development using the PPP Scheme

As explained in 5.1.2, PPP has been used mainly for hospitals and very rarely for railway projects. The reason is that PRASA has been receiving large sums of grant money from the national government and provincial governments so it can undertake projects on its own.

TRANSNET has enough capability to procure funds on its own. There is very little chance for PRASA and TRANSNET to use PPP to finance projects. Based on the above, it is almost unlikely that PPP scheme will be used for railway development/upgrade based on the PRASA and TRANSNET investment plans. Basically, provincial governments and local governments are considered suitable targets for PPP projects.

Gautrain is the only railway project built using the PPP scheme. Gauteng province provided certain amount of capital and provided ridership guarantee to the SPV. However, there is no guarantee that there will be continued public support to SPVs in the future. As mentioned in 5.1.2, from the viewpoints of other provincial governments, Gautrain is a special case that has received tremendous support from the national government. Some believe that PPP is difficult to apply at this time. On the other hand, Gautrain's fare is higher compared to the other urban railways. It will be difficult for other projects to charge a higher fare level than that of the Gautrain.

Based on the above, it is believed that the PPP scheme will mainly be used for publicly supported railway projects that are strongly promoted by the provincial governments, local governments, or the Parliament, etc. and that have the strong support of the national government.

5.4 Brief Review of Social/Economic/Environmental Impacts of Current Investment Plans

5.4.1 Socio-economic Effects

The South African government is expecting community development, direct/indirect economic effects, increased employment, and other investment effects through industrialization/modernization of the railway sector and local production. Such expectations can be seen from the summary of new growth policies shown in Table 5-3 and the summaries of interviews with major construction companies.

In addition, the use of BEE companies is highly emphasized as a policy. The BEE Act, shown in Table 5-3, requires high BEE score for companies high in the supply chain. This was also pointed out in interviews with major construction companies, as shown in Table 5-4. In other words, when promoting modernization of the railway sector, it is necessary to consider the BEE Act when reviewing investment plans.

It has become a topic in our interview with the Free State Department of Agriculture and Rural Development (DARD), as shown in Table 5-4, that South Africa needs to strengthen the human resources development function of the School of Engineering under TRANSNET and the Training Academy under PRASA. In other words, it is necessary to take a close look at human resources development when reviewing the investment plans.

Since the labor unions are powerful, employment issue may affect the investment plans. ASGISA and others have been established to resolve employment issues, as shown in Table 5-3. In our interview with the Free State Department of Agriculture and Rural Development (DARD), the Study Team heard comments showing the expectation of jobs creation from railway development.

However, there is the risk of not being able to form consensus among the operators of transportation modes. This was pointed out in our interviews with major construction companies, as shown in Table 5-4.

Table 5-3 Main Contents of Relevant Laws and Regulations and Their Relevance to Railway Projects

Name of law	Main points	Relevance to railway projects
Broad-Based Black Economic Empowerment Act, No.2003/ BEE） (BEE Act)	・Requires all companies conducting business in South Africa to promote the participation of black people in economic activities. ・BEE achievement level is considered in government procurement. Raising BEE shareholding ratio is a condition for granting permit to mining and banking operators.	・A full score of 100 points is derived from criteria, including equity ratio (target 25%), procurement rate (target 70%), and so on, based on the participation level of black people in the project. The score is evaluated when a bid is tendered.
Medium Term Strategic Framework (MTSF)	・It is a concrete form of the political pledge of the parliament during the 2009 election. It provides a national strategic framework for the 6 years between 2009 and 2014 and lays out the priority of development issues.	・Indicates as some of the priority development issues in the transition to an economy of accelerated growth, job creation, and sustainable livelihood.
New Growth Path (NGP)	・Provides long-term national economic policies for South Africa until 2020	・Advocates a policy target of creating jobs for 5 million people and lowering unemployment rate to 15% by 2020.
National Development Plan 2030 (NDP)	・Presents employment and other targets until 2030	・Advocates a policy target of creating jobs for 11 million people and lowering unemployment rate to 6% by 2030.
Accelerated and Shared Growth Initiative for South Africa (ASGISA)	・ASIGSA is a strategy formulated after many deliberations between the concerned government departments and the Premiers of the National Council of Provinces. It serves as the basis of industrial policies.	・Points out that scarcity of skilled workers, regional gap in the labor cost of low- skilled workers, and other constraints that are deterring the economic growth of South Africa.

Source: Compiled by Study Team

Table 5-4 Opinions and Information from Interviews

Interviewee	Major opinions and information
Free State Department of Agriculture and Rural Development (DARD)	・Revitalization of the railway network can create more jobs, which will have economic ripple effect. ・Restoration of the railway branch lines is highly effective in creating jobs in agricultural villages. In particular, revitalization of the railway branch lines is extremely important to the modernization of railways in South Africa.
Free State Department of Agriculture and Rural Development (DARD)	・Besides freight trains, we also have need for high-speed passenger railway. The bus route between Bloemfontein and Botshabelo, which had received government subsidies for the past 25 years, failed to get renewal for the subsidies. This is because the provincial government wants to secure grant money for the passenger railway. Effects from the promotion of railway transport on other transportation modes and the social economy as a whole shall also be considered.

KwaZulu-Natal Department of Agriculture, Environmental Affairs and Rural Development (DAEARD)	・The government of South Africa views job creation and utilization of BEE as the motive power for social development.
Major construction company	・During procurement , we are asked to submit the scorecard to the BEE suppliers. Since our company is at a relatively high position in the value chain, we certainly need a high score. We are working very hard to get a high BEE score. ・To obtain public construction projects from the government, we are required to hire certain number of non-skilled workers. For this reason, we sometimes have difficulty moving the project forward smoothly. ・The labor unions are very powerful, especially the parastatal ones. It is not easy for foreign companies to negotiate a labor contract.

Source: Compiled by Study Team

5.4.2 Effects on the Environment

In the case of railway, when a railway project straddles multiple provinces, the concerned provincial governments will participate in the deliberation. However, as shown by the results of interviews at the Department of Environment and Tourism in Table 5-6, the ultimate decisions are made by the national entities (DOT, etc.). Therefore, when reviewing investment plans, it is necessary to pay attention to the actions of the national entities, such as DOT.

Since the TRANSNET and PRASA plans mostly focus on the upgrade and improvement of existing facilities on the existing lines, the risk of land expropriation is not high. Table 5-5 gives an overview of the Land Expropriation Act. In general, railway projects are expected to be received positively by residents, the risk of lawsuits from them is not high. This can also be seen from the results of interviews conducted at the national government's Department of Environment and Tourism shown in Table 5-6.

However, some of the projects for the construction of new lines being planned at this time may require the implementation of environmental impact assessment (EIA). Since an EIA needs to follow many steps in order, the implementation period will be long. Delay of the investment plan is conceivable. As shown in Table 5-6, this was pointed out by a major construction company during the interview.

Table 5-5 Major Contents of Relevant Laws and Regulations and Their Relevance to Railway Projects

Name of law	Major contents	Relevance to railway projects
National Environmental Management Act, No. 107 of 1998/NEMA	・NEMA was enacted to replace 17 provisions in the Environment Conservation Act (ECA) promulgated in 1989. However, it does not include waste management, noise, and the environment, etc. ・With the enactment of NEMA and other laws, some of the ECA provisions have been abolished	・" NEMA imposes duties on owners, controllers, or users of such land or buildings to consider the environment and take specific measures for such considerations. " ・Article 35 of NEMA mentions establishment of the "Environmental Management Co-operation Agreement/EMCA." In the future, an "Environmental Management

	or amended. However, the law continues to exist with the remaining contents.	Co-operation Agreement" mechanism will be set up. The system will enable the local governments of concerned areas and all potential stakeholders and local communities to discuss the railway projects and make decisions for the design, construction, operation, and maintenance of the railway facilities.
Environment Conservation Act (ECA)	・After ECA was promulgated in1989, it was amended by various laws and regulations, such as NEMA. However, it still exists as an important piece of environmental legislation.	・The law mandates environmental impact assessment (EIA). ・The law gives the Department of Environmental Affairs and Tourism (DEAT) authority to list activities requiring EIA. The department provides guidelines on the implementation method of EIA.
National Water Act (NWA)	・It stipulates authority of the government over water management, priority in protecting the aquatic ecosystem, and application for water use license for the implementation of projects.	・The law stipulates application for a water use license to carry out railway construction. In particular, in the western part of South Africa, where it is dry, the law focuses on the application of a water use license for implementing a project.
National Heritage Resources Act (NHRA)	・The law stipulates the principles for managing all the heritage resources in South Africa. The scope of heritage resources covers heritage sites designated by the national or provincial governments (archaeological and paleontological sites, burial grounds and graves, memorial architecture, monuments, etc.)	・Since the TRANSNET and PRASA plans target mostly the existing lines, the risk of being subjected to this law is low.
Land Expropriation Act	・The Land Expropriation Act gives authority to the Department of Public Work (DPW) to expropriate or temporarily borrow private assets for public purposes, with the payment of compensation. ・The compensation is calculated based on market value.	・Since the TRANSNET and PRASA plans have few construction plans for new lines, the risk of land expropriation is not high.

Source: Compiled by Study Team

Table 5-6 Major Opinions of and Information from Interviewed Entities

Interviewed entity	Major opinions and information
Department of Environmental Affairs and Tourism (DEAT), personnel in charge of EIA evaluation	• Since railway projects are the projects of national agencies, the Department of Environmental Affairs (DEA) has oversight over the environmental aspect of the projects. Since the TRANSNET and PRASA plans do not have the specifics yet, we cannot say what is needed from the perspective of environmental impact assessment (EIA). However, the purchase or replacement of rolling stock alone will not require EIA. On the other hand, track upgrade, bridge expansion, and construction of new stations will likely require EIA. ・Projects transcending provincial borders and projects of national companies, such as PRASA and TRANSNET, are under the jurisdiction of DEA. • New construction faces high risk of lawsuits from residents, which might lead to plan delay. However, since the TRANSNET and PRASA plans focus on the upgrade and improvement of existing facilities, they are expected to be viewed favorably by residents. Therefore, the risk of lawsuits is not high.
KwaZulu-Natal Department of Agriculture, Environmental Affairs and Rural Development (DAEARD)	・Railway projects are under the jurisdiction of the national government's Department of Environmental Affairs. The provincial governments will participate in the discussions but the national government has the final say. ・The Environmental Management Co-operation Agreement/EMCA is a proposed mechanism but it has yet to be put into practice.
Major construction company	・Usually, the entity ordering the construction hires a third-party consultant to perform Social Impact Analysis (SIA) and Environmental Impact Analysis (EIA) and formulate an Environment Management Plan. Our company carries out the construction based on this environment management plan. This process sometimes takes 4–5 years. Therefore, the entity ordering the construction shall start applying for EIA from the planning phase of the project. ・Since projects to upgrade existing lines have little impact on the surrounding environment, implementation of EIA is not required in many cases. ・In dry areas such as the western part of South Africa, water use during construction is especially an environmental concern.

Source: Compiled by Study Team

5.5 Decision-making Mechanisms of the Department of Transport, Department of Public Enterprises, and Provincial Governments

This section summarizes the decision-making mechanisms of the Department of Transport, Department of Public Enterprises, and provincial governments. It identifies the risk of delay in the implementation of a railway project from the perspectives of those mechanisms.

5.5.1 Roles and Discretion of Departments and Personnel Responsible for the Planning of Railway Projects in Major Entities

(1) National Government

The Department of Transport (DOT), Department of Public Enterprises (DPE), and National Treasury of the national government are involved in the implementation of railway projects. As shown in Figure 5-17, with each entity fulfilling its role shown in 1) to 3) below, the

government is able to monitor consistency in the operations of national enterprises PRASA and TRANSNET with transport policies and their financial soundness.

1) Department of Transport (DOT)
DOT, as a policy department, makes policies and at the same time, monitors if the operations of state owned enterprises PRASA and TRANSNET are working towards the achievement of policy objectives.

According to the Public Finance Management Act (PFMA), national companies are required to report their financial conditions to the presiding departments and National Treasury on a regular basis. This enables DOT to monitor the financial condition of PRASA.

The Minister of Transport is the Executive Authority of PRASA. The executive Authority, as a shareholder, monitors the prospect of fair returns on investment and financial viability. It also approves the corporate plan of PRASA. For PPP projects, the National Treasury performs the same functions.

NT makes decision on budget appropriation to PRASA and DOT distributes the budget. DOT does not have the authority to appropriate budget.

2) Department of Public Enterprises (DPE)
The role of DPE is to perform shareholder management for the State Owned Enterprises (SOEs). DPE is the shareholder of nine SOEs, including TRANSNET. It also sends directors to the boards of these companies. DPE is the only shareholder of TRANSNET.

As explained in 1), national companies have the obligation to report on a regular basis their financial conditions to the presiding departments and NT, pursuant to PFMA. This enables DPE to monitor the financial condition of TRANSNET.

Furthermore, the Minister of Public Enterprises is the Executive Authority of TRANSNET. As explained in 1), the executive Authority, as a shareholder, monitors the prospect of fair returns on investment and financial viability. It also approves the corporate plan of TRANSNET.

3) National Treasury (NT)
Pursuant to the Constitution of the Republic of South Africa, the National Treasury procures funds for the government, prepares budgets, and ensures compliance with laws and regulations. It has discretion in budget-related matters, including the appropriation of subsidies to PRASA through DOT. For this reason, it determines whether to implement a project or not from a funding perspective. As explained in Chapter 2, NT will determine the feasibility of PPP projects. When NT looks at the financial analysis of a PPP project, it looks at the Considerable reserve, Loan cover ratio, Performance bond, and Cost of insurance.

NT is also responsible for the oversight of National Revenue Fund and sovereign credit rating. Therefore, NT has the following functions based on PFMA, namely, to ensure transparency in and effective management of the revenue/expenditure and assets/debts of national companies, approve and evaluate new entities planning to set up national companies, accept corporate plans, accept the drafts and final versions of annual financial statements, and monitor the borrowing plans of national companies.

(2) Provincial and Local Governments

National companies (PRASA and TRANSNET) are responsible for the formulation and implementation of railway investment plans. The provincial governments have oversight of the plans. Specifically, with regard to the implementation of the Provincial Land Transport Framework (PLTF), the provincial government monitors if the national company can contribute to the project or if PRASA, which receives grant money from the province, is using the grant

money appropriately. As in the case of the national government, the transportation bureau and finance bureau of the provincial government are responsible for the monitoring. The Minister Executive Committee (MEC), which is equivalent to the ministers of departments in the national government, plays an important role in decision-making.

As explained in (1), the corporate plans of national companies receive approval from the presiding departments (DOT, DPE) and NT, which is the finance department. In order to ensure that the corporate plans work well with the plans being formulated by the provinces and cities and with the budgets for realizing those plans, national companies exchange opinions with the provinces and cities from the start when they formulate the corporate plans.

When it is necessary to acquire land for the construction of a new railway line, the local government that manages the land will get involved.

(3) Parliament

The Constitution of the Republic of South Africa assigns to the Parliament and national councils, the role to oversee national companies and the ministers who are their executive authorities (MEC at the provincial level), and the Cabinet formed by ministers.

The Parliament has two committees made up of members of the Parliament. They evaluate the performances of national companies based on their annual financial reports. One is the Standing Committee on Public Accounts (SCOPA). It conducts audits based on annual financial reports and examination reports issued by the Auditor General. The other is the Portfolio Committee. It audits the pertinence of services provided by national companies; that is, the provision of services not covered under the financial aspect of the annual reports and the contribution of national companies to economic growth. The various departments explain their budget proposals to these committees, where the budget proposals are deliberated.

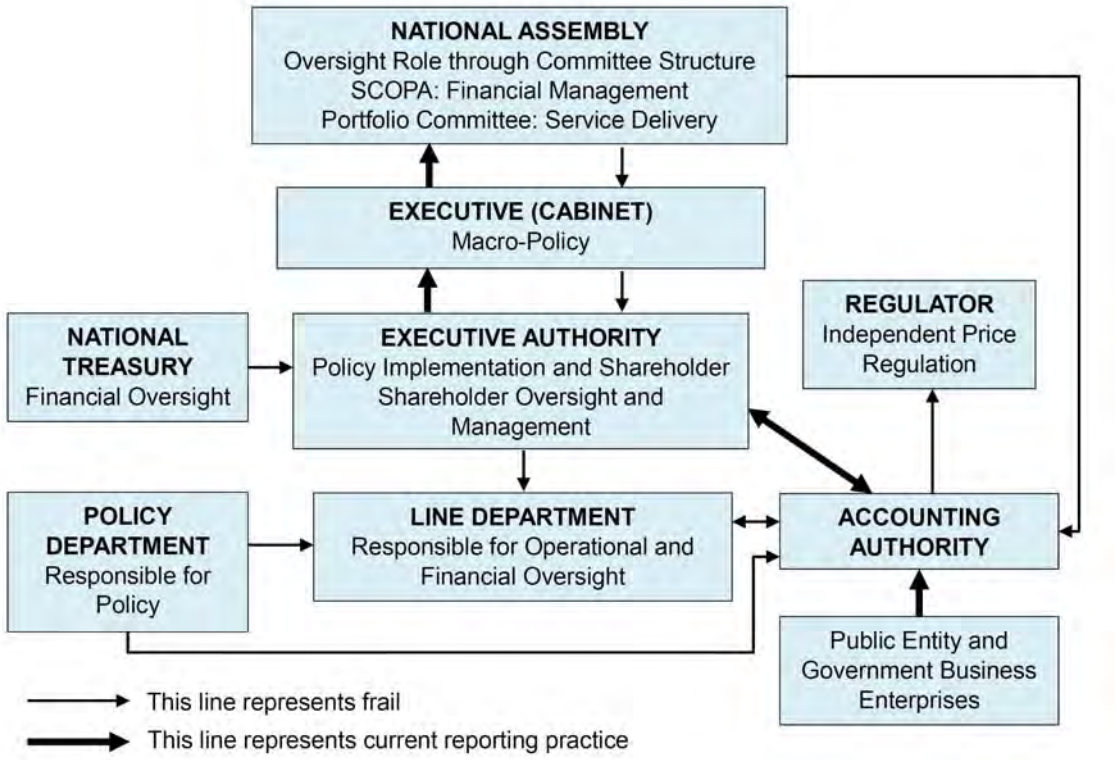
For example, the risk that the Portfolio Committee on Transport does not replace old rolling stock has been pointed out. It is said to have a big impact on the approval of the PRASA rolling stock replacement plan.

In general, when a decision is made at the Parliament, it is necessary to form a consensus between the politicians and the government.

(4) State Owned Enterprises (SOEs)

State owned enterprises are entities operating to fulfill the roles stipulated in the laws or corporate plans under the governance and supervision of the Parliament, presiding ministers, and finance authorities. For example, the role of PRASA is stipulated in the Legal Succession to the South African Transport Services Act of 1989 and in its corporate plan.

The Board of Directors of SOEs and accounting bureaus are the internal governance organizations of state owned enterprises. The board of directors of a SOE has absolute responsibility and accountability for the performance of the state owned enterprise. The accounting bureau has the responsibility for managing financial matters and accountability.



※ In terms of transport policy, DOT plays the roles of both a policy department and an line department. For example, in the case of energy policy, the Department of Energy is the policy department and Eskom is the line department under DPE.
※Accounting bureau is an internal organization of a SOE.

Source: NT "GOVERNANCE OVERSIGHT ROLE OVER STATE OWNED ENTITIES (SOE's)"

Figure 5-18 Roles of Main Entities and Their Relationships

5.5.2 Decision-making Mechanism for the Implementation of Railway Projects

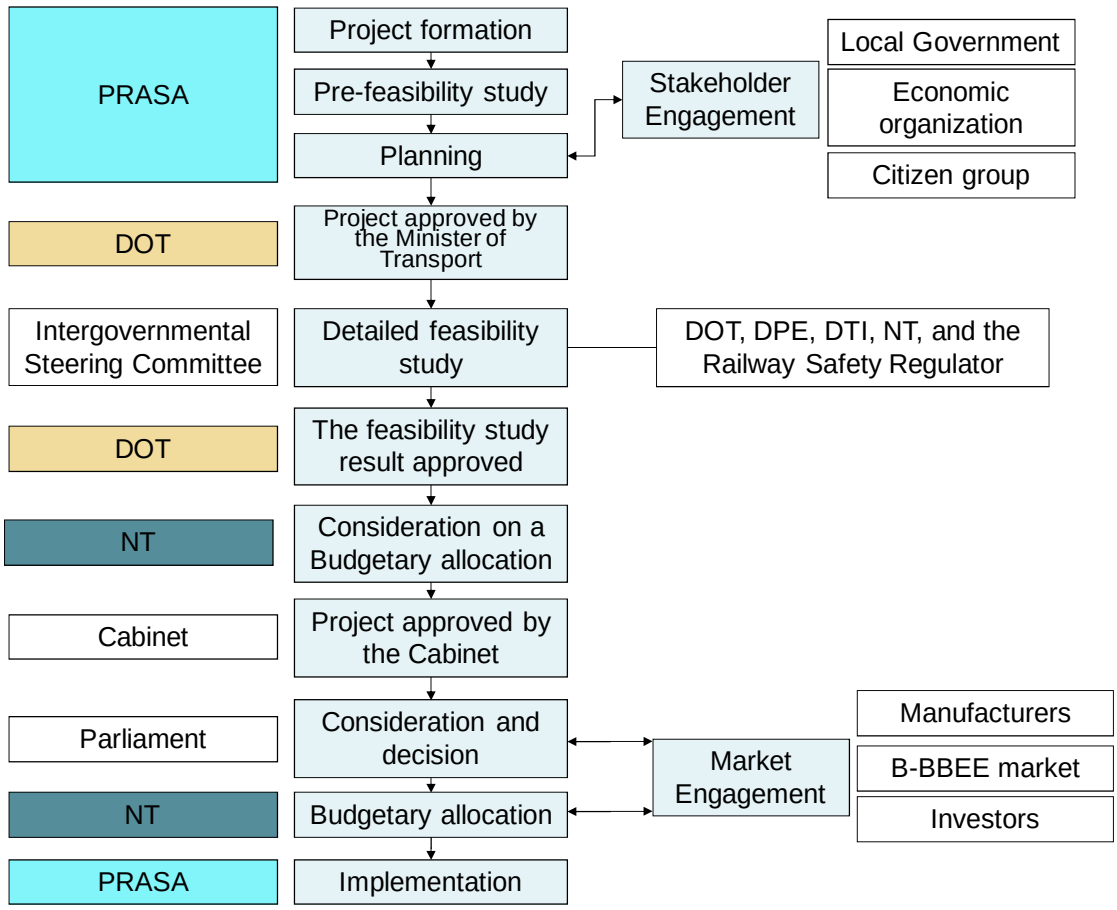
(1) Decision-making Mechanism for the Implementation of Projects

As shown in Figure 5-19, the decision-making flow of railway projects by SOEs (PRASA, TRANSNET) is greatly affected by the governance and supervision systems stipulated by PFMA, as explained in 5.5.1, the previous section.

More specifically, an SOE has to submit a 3-year corporate plan and expenditure results, and reports annually and monthly on the status of target achievement. In accordance with these provisions, the presiding department DOT/DPE and the financial department NT govern the SOE. For example, to raise funds, an SOE has to submit a corporate plan to the minister of the presiding department and the NT. After having approved by the department, the applied plan is submitted to the Parliament. If the plan is approved by the Parliament, grant money will be given to the SOE through the presiding department. The SOE can also raise funds from the capital markets.

PRASA has incorporated stakeholder engagement in the decision-making and implementation process. It explains the draft plans to the provinces, cities, economic organizations, citizen groups, and businesses and listens to the opinions of the various entities. TRANSNET has also started to undertake similar initiatives.

Detailed feasibility studies conducted by PRASA and TRANSNET are also incorporated into the decision-making process. For the implementation, an intergovernmental steering committee is set up jointly by concerned departments, including NT, DOT, DPE, and DTI, to supervise the implementation and to approve the contents of the studies.



Source: Compiled by Study Team

Figure 5-19 Decision-making of Projects at PRASA

Such process to make decision while listening to the opinions of concerned parties takes time and effort. However, it is a necessary process for developing national land and cities as it can enhance the use of railway, increasing local procurement rate, and expanding the economic ripple effect in the future. The risk does not lie in listening to the opinions of concerned parties but rather in not listening to the opinions as the plan may have loopholes or may not be accepted by the market. The shortage of management and technical personnel in each entity may pose a risk in delaying the process.

For reference, Figure 5-18 shows the decision-making process (1) of the PRASA rolling stock procurement program. Table 5-7 summarizes the specific decision-making process of the PRASA rolling stock procurement program in FY 2011.

Table 5-7 A Process PRASA decides the Rolling Stock Fleet Renewal Programme

Process	Date
Submission of a programme made by PRASA to the Minister of Transport	
Rolling Stock Fleet Renewal Programme approved by the Minister of Transport	
Intergovernmental Steering Committee founded by DOT, NT, DTI, DPE, and the Railway Safety Regulator, and supervise the programme	
Funding the fund for the detailed feasibility study by the NT	February 2010
Appointment of a Transaction Advisor	
Start the detailed feasibility study on Rolling Stock Fleet Renewal Programme (by the Intergovernmental Steering Committee)	
The Minister of Finance confirms the programme on the Budget Speech.	February 2011
Conduct a market engagement[3]	April 2011
Conclude the detailed feasibility study and approved by Intergovernmental Steering Committee, PRASA Group EXCO and Board	Early June 2011
Submission of the study results to the Shareholder – DOT	Mid June 2011
Submission of the study results to the NT	End-June 2011
Submission of the Cabmemo to the Cabinet	July 2011
Consideration on the Portfolio Committee on Transport	September2011 ~November 2011
Project approved by the Cabinet	November 2011
B-BBEE Market Engagement	November-22 2011
Funding arrangements finalised	February 2012
Market engagement on local content with local suppliers and rolling stock manufacturers	February 2012 ~March 2012
Issue Request for Proposal	April 2012
Proposal closing and approval of the preferred bidder	End-September 2012
Signing of contract and placing of order	November 2012
Recommendation of selected bidder and technology to the Cabinet	February 2013
Reach financial close with preferred bidder	June 2013

Source: Compiled by Study Team

As a program, PRASA generally appropriates the budget internally to individual projects based on the budget appropriated by NT through DOT. However, for PPP projects or projects requiring highly political consideration (large-scaled projects, etc.), approval from DOT and NT for individual projects may need to be obtained.

(2) Decision-making Mechanism for Corporate Plans

PFMA stipulates that public entities, including state owned enterprises, shall prepare corporate plans, which are 3-year mid-term plans, and obtain approval from the Parliament. A corporate

[3] A market engagement is a briefing to a market to provide information and collect opinions. It is required by the present South African industrial policy. It helps a rolling stock industry secure the minimum requirement of a customer for an investment and the capacity to supply the large amount of rolling stocks suited for local requirements. It also helps a financial business secure the capacity to provide long-term fund.

plan covers the mid-term goals of a national corporation, such as PRASA and TRANSNET, strategies, indexes to gauge performance, operation plans, investment plans, financing plans, procurement plans, risk management plans, and financial plans (revenue/expenditure, loan prospect, assets/debt management, cash flow forecast, capital spending program, dividend policy, etc.). To be included in the corporate plan is a favorable factor in the decision-making of a railway project implemented by state owned enterprises.

The decision-making process is explained below. First, PRASA prepares a corporate plan and obtains approval from the Board of Directors. It sends the plan to the presiding department DOT for application. Once the plan is approved by DOT, it will be sent to the Cabinet (Portfolio Committee on Transport) for deliberation in order to obtain approval from the Parliament.

5.5.3 Risk of Delay in the Implementation of Railway Project Viewed from the Decision-making Mechanism

As summarized in 5.5.1 and 5.5.2, many entities are involved in the implementation of a railway project. Each entity conducts the necessary review based on its function. For example, NT monitors the financial aspect and DOT ensures the implementation of transport policy. Stakeholder engagement for provincial governments and economic entities, and market engagement for manufacturers are carried out to ensure integration with local transport policies to enhance railway use. The necessary procedures are taken to boost local procurement.

Rather than the relationship between entities, the shortage of a skilled workforce and other causes being reviewed internally by each entity are the risks that shall be addressed.

5.6 Economic Ripple Effect

The national and provincial governments are anticipating economic ripple effect (including job creation effect) from the implementation of projects. Therefore, in this section, the Study Team analyzed the economic ripple effect of the investment plans for the railway sector and reviewed based on the degree of the impact if supports from the national and provincial governments are adequate for the implementation of the investment plans.

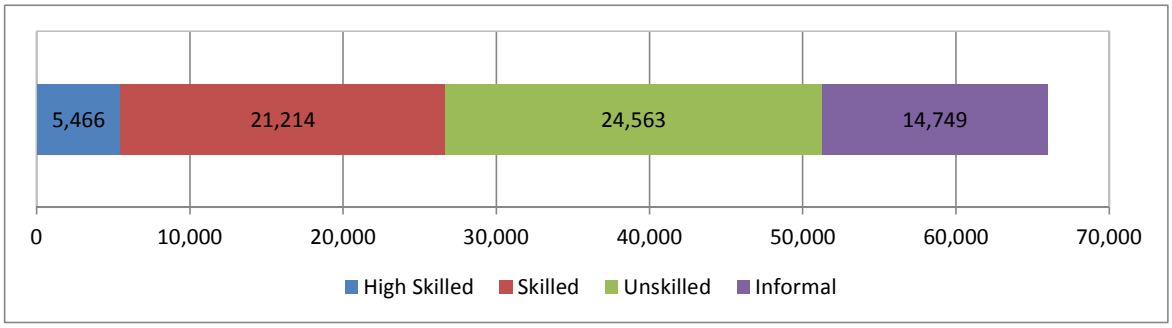
Rolling stock, track, signal, electricity, civil engineering, and other support industries have taken root in South Africa. Investment in the railway sector will not only increase the production amounts (direct effect) of various industries, including component manufacturers for railway rolling stock and construction companies but also generate secondary demand in other industries that deal with these industries to further increase and expand production (first ripple effect).

5.6.1 Calculating the Economic Ripple Effects by PRASA

PRASA calculated the economic ripple effect of its investment plan from the introduction of new rolling stock. From the characteristics of the output, interindustry analysis is believed to have been the method used for the calculation. ① Job creation effect, ② Revenue effect for the South African government, and ③ Business benefits are the three elements used to calculate the economic ripple effects.

(1) Job Creation Effect

According to PRASA, the investment will create 65,992 jobs.

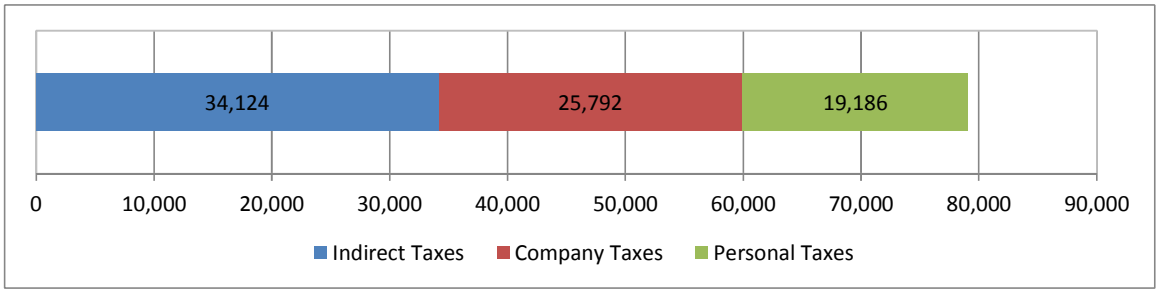


Source: PRASA Feasibility Study, July 2012

Figure 5-20 Job Creation Effect according to PRASA Investment Plan (Unit: person)

(2) Effect of Tax Revenue Increase

The project cost for new PRASA investment totals 102 billion ZAR. Of the amount, approximately 79.1 billion are taxes that will become government revenue. In other words, according to PRASA analysis, over 70% of the project cost will be tax revenue and the funds will be circulated inside South Africa.

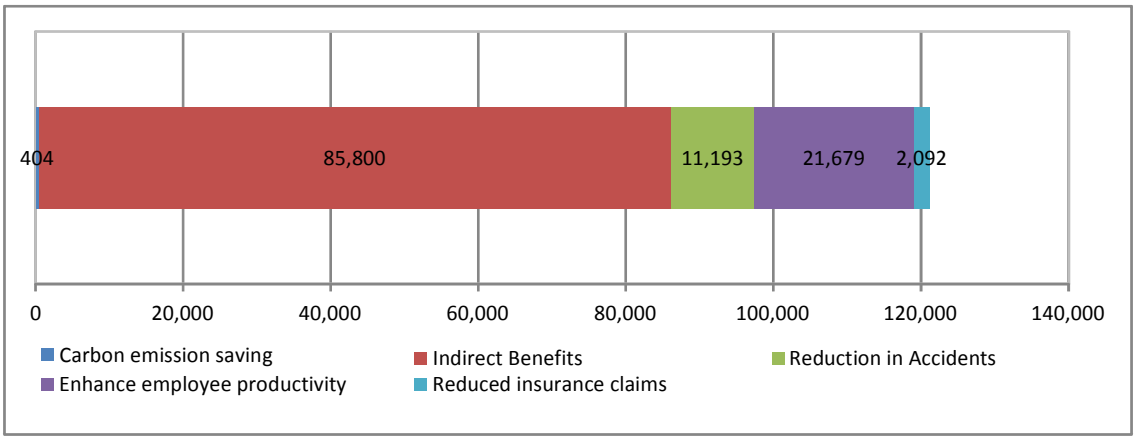


Source: PRASA Feasibility Study, July 2012

Figure 5-21 Effect of Tax Revenue based on PRASA Investment Plan (Unit: million ZAR)

(3) Business Benefits

A trial calculation is performed of the various benefits that PRASA will generate from its project investment. The biggest effect will be indirect benefits.



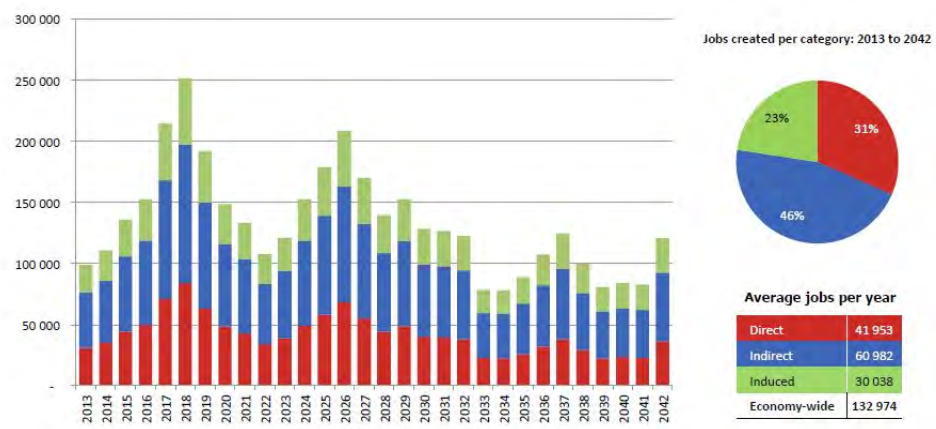
Source: PRASA Feasibility Study, July 2012

Figure 5-22 Projects Benefits based on PRASA Investment Plan (Unit: million ZAR)

5.6.2 Reviewing Trial Calculation of Economic Ripple Effects by TRANSNET

TRANSNET reviews the economic ripple effects by dividing them into three phases: economic, social, and environmental. Although it does not evaluate quantitatively the ripple effects on the economy as a whole, it finds qualitative effects from industrial development and human resources development. In terms of the environment, since TRANSNET is responsible for approximately 1% of South Africa's greenhouse gases emission, improvement in energy efficiency at TRANSNET will contribute to the reduction of greenhouse gas emissions.

TRANSNET calculated the job creation effect from its investment plan. At the time, the scope of employment reviewed included (1) Direct employment (newly hired by TRANSNET and newly hired by employers who have orders from TRANSNET projects; (2) Indirect employment (hiring at companies that supply products to TRANSNET and companies that receive TRANSNET orders); and (3) Other employment (jobs created from consumption by TRANSNET employees). According to TRANSNET, new jobs will be added to the current employment level of 100,000 people. The employment is estimated to maintain at an average of 132,974 jobs annually for the next thirty years.



Source: TRANSNET "Long Term Planning Framework 2012," 2012

Figure 5-23 Job Creation Plan based on TRANSNET Investment Plan

5.7 Risk Factors of Investment Plan for the Railway Sector

In this chapter, the Study Team identified and analyzed the various risk factors related to the investment plans and projects of the railway sector and reviewed ways to reduce or hedge the risks. The following are the risk factors, its contents, and countermeasures.

Table 5-8 Contents of Risk Factors and Countermeasures

Risk factor	Contents of risk	Measures to counter risks
Financial conditions of the national and provincial governments	Reduction in subsidies and financial guarantees	Serious risks of reduction in tax revenue and demand if the European debt crisis worsens.
Future demand	Reduction in revenue	
Prospect of financing	Failure to raise funds	The current TRANSNET financial condition does not present any problem. Only if the financial condition deteriorates seriously due to decline in demand, some problems may occur.

Land acquisition and environmental regulations, etc.		Time required for acquiring land and complying with environmental regulations, etc.	No problem since there is no construction of new lines
Decision-making/ management, etc.	Procedures for decision-making and formation of consensus	Time required for decision-making and formation of consensus	It is assumed that the decision-making process is a necessary procedure that ensures effective implementation of the projects and creates greater effect in the mid-to-long term. It shall be noted that when it is necessary to import from overseas, the market engagement to obtain the opinions of market participants, which is a part of the decision-making process, will also include foreign companies.
	Inadequacy in planning and management	Without sufficient coordination between other transport modes, such as buses from the stations, and the development of station vicinities, the use of railway will not increase.	In tandem with initiatives such as Stakeholder Engagement, it is possible to address this risk by establishing an integrated transport mode organization recommended by NATMAP.
	Shortage of skilled workforce	The project cannot proceed as planned due to shortage of skilled workforce	As recommended by this survey, it is necessary to enhance human resources development.
Economic effects		If the economic effects are small, the society does not see the necessity for implementing the projects.	Job creation and other considerable economic effects are identified. With regard to the job creation effect, although it is questionable if the targeted local contents ratio can be achieved, the possibility of realizing the job creation effect is high due to market engagement and other initiatives to increase the ratio of local contents.

Source: Compiled by Study Team

Chapter 6

Initiatives of Private Sector and Other Countries

Chapter 6 Initiatives of Private Sector and Other Countries

6.1 Initiatives of Japanese Companies

6.1.1 History of Japanese Companies Making Entry into South Africa's Railway Market

(1) 1970s–1980s

Together with Nissho-Iwai, Hitachi and Toshiba received orders from SAR (South African Railway) at the beginning of the 1980s and entered the South African market.

Furthermore, Mitsui, as a contractor, and Toshiba, as a subcontractor of electrical equipment, succeeded in obtaining orders from South African Transport Services (SATS). They imported electrical equipment from Japan and assembled rolling stocks at Union Carriage & Wagon (UCW). Under the same collaboration systems, Mitsui and Toshiba received orders from TRANSNET even in later days. At that time, UCW was manufacturing both the locomotives and electric trains in South Africa. It had excellent organization and engineers. The Series 10E and 10E2 electric locomotives manufactured at that time have few problems. They are still in active service today.

On the other hand, Hitachi cooperated with the former Nissho Iwai (currently known as "Sojitz") and succeeded in obtaining an order for 96 electric trains from SATS (currently known as "PRASA"). The rolling stock was manufactured at DCD-Dorbyl.

(2) 1990s–2000s

Toshiba set up an office at Johannesburg in 1967. At the end of Apartheid in 1989, it closed down the office because of political instability and disruption of civil life. After the launch of Mandela's new government in 1994 and his racial reconciliation policy, the office reopened in 1997 because Toshiba anticipated demand from not only the railway sector but also the electric sector.

In the 1990s, due to the abolition of Apartheid, together with regime change and the effect of increased expenditure for the living and environmental sectors, the budget allocation to the railway sector was reduced. No new locomotives or electric trains were procured. Given the aging locomotives, TRANSNET decided to purchase locomotives in 2002, after twenty years. It announced bidding for the Series 19E and 15E electric locomotives. Mitsui/Toshiba and Siemens tendered bids and Mitsui/Toshiba were successful in winning the bid.

Mitsui/Toshiba tendered the bid, expecting to produce the rolling stock at UCW. After succeeded in winning the bid, they found out that UCW no longer had the technical capabilities or the engineers that it had in the 1980s. The reasons are manifold. Besides the disorder before and after the abolition of Apartheid, there was no new investment for twenty years. The UCW operation was limited to the restoration of only about 100 units of electric cars per year and the white engineers have moved overseas. As a result, production could not proceed as originally planned.

To break this gridlock, UCW replaced its president. In addition, Toshiba dispatched to UCW as many as 20 engineers in South Africa, which is the No. 2 market after China, to facilitate technical transfer (design, manufacturing, and testing). During the two and a half years from 2008 to 2010, comprehensive training from basic operation to quality control was provided.

In 2002, only UCW and TRE were manufacturing locomotives in South Africa. Based on the performance from the 1980s, Mitsui/Toshiba decided to join forces with UCW.

After receiving an order for 96 units of Series 8M electric train, Hitachi received another order to upgrade the 7E1. Today, it has withdrawn from the South African market.

Some characteristics of Japanese companies in recent years are: 1) Rather than tendering bid on its own, a manufacturer will join forces with a trading company for the bidding and 2) Japanese companies continue to participate in the market without having their own factories in South Africa.

With regard to 1), a role-sharing cooperative system is set up with the manufacturer concentrating on the technical aspect and the trading company utilizing the network in South Africa to establish a cooperative relationship with local suppliers. 2) has many reasons, such as not enough demand in South Africa until now, high labor cost, strong resistance from labor unions, insufficient ongoing profits in relation to the cost of setting up new factories, and shortage of skilled suppliers, and so on.

From the perspective of the customers TRANSNET and PRASA, the ability to provide continued services at advanced technical level, including maintenance service, is important. Therefore, it is conceivable that Japanese companies will be asked to expand operation by setting up factories in South Africa and so on.

Table 6-1 Delivery of Rolling Stock by Japanese Companies

Delivery date/ Contract year (Note 1)	Vender	Customer	Type of rolling stock delivered/ quantity	Remarks
1980-1985 /Beginning of 1980s	Hitachi/Nissho-Iwai (Currently known as "Sojitz")	SAR (South African Railways, Currently known as "TRANSNET")	7E1/50 units 7E3/85 units	・Final assembly at Dorbyl
－ /1983	Mitsui/Toshiba	SATS (South African Transport Services, Currently known as "PRASA")	Series 10E/ 10E2 electric locomotives/ －	・Toshiba is the subcontractor for electric equipment and UCW (Union Carriage & Wagon) is the subcontractor for machinery.
1983-1984／－	Hitachi/Nissho-Iwai (Currently known as "Sojitz")	SATS (South African Transport Service, Currently known as "PRASA")	Series 6M EMUs/ 12 cars	・Final assembly at Hitachi
1985–1992/－	Mitsui/Toshiba	TRANSNET	Series 10E /10E2 electric locomotives/ 75 units (50 units of Series 10E and 25 units of Series 10E2)	・UCW did the final assembly ・Transport iron ores using Kimberley as the base

1991/－	Hitachi/Nissho-Iwai (Currently known as "Sojitz")	SATS (South African Transport Service, Currently known as "PRASA")	Series 8M EMUs/ 96 cars	・Final assembly at Dorbyl
August 2008 –October 2012/ February 2006	Mitsui/Toshiba / UCW	TRANSNET	Series 19E electric locomotives/ 110 units	・Toshiba stationed about 20 engineers at the UCW locomotive plant to train and supervise the manufacturing and testing of locomotives (Note 2) ・The electric locomotives are used to transport coal on the approximately 450-km line from coalfields in the inland to Richards Bay, a port on the Indian Ocean coast. The planned annual transport volume is 92 million tons.
August 2009–May 2011/ 2006–2010 (Note 3)	Mitsui/Toshiba / UCW	TRANSNET	Series 15E electric locomotives/ 76 units (32+12+32 units) (Note 3)	・The electric locomotives are used to transport iron ores on the approximately 861-km line from Sishen to Saldanha, a loading port on the Atlantic Ocean coast. The planned annual transport volume is 41 million tons.

(Note 1) There was no delivery of rolling stock from 1992 to 2008 because of the effects of Apartheid. The Toshiba office was closed before the Apartheid-related political disturbances in 1989 to 1996.
(Note 2) The levels of design and manufacturing technologies at UCW were low. It was necessary to supervise the manufacturing and testing. The low level of design and manufacturing technologies is due to a long period without any demand for the manufacture of locomotives and the immigration of white engineers overseas at the end of Apartheid in 1994.
(Note 3) The contract date for the delivery of 32 units was October 2006, with the option of additional 12 units to be delivered in 2008 and 32 units in 2010.
Source: Compiled by Study Team based on Toshiba information materials and interviews at Mitsui & Co. African Railway Solutions (pty) Ltd.

6.1.2 Challenges of Localization and Solutions

Currently, the standard that TRANSNET uses to procure for the general freight business (GFB) requires a 65% local production rate of the locomotive as a whole and 80% for electric equipment 3 years after receipt of the order. Since it is difficult to manufacture electronic parts (elements) and printed wiring board in South Africa, the chance of meeting the requirements is low.

Despite the fact that localization is a prerequisite, companies are faced with problems such as the low technology level mentioned above, high labor cost, lack of cost-effectiveness in setting

up new plants without the prospect of ongoing demand in the future, and strong resistance from labor unions. From a political perspective, enforcement of the BEE Act will become increasingly strong. These are reasons that make local production difficult.

According to our interview with Toshiba, since it is extremely difficult to meet the requirements of localization, Toshiba hopes that the manufacture of electronic parts (elements) and printed wiring board will be exempt from localization.

Compared to foreign companies that have already established manufacturing bases in South Africa, the environment for Japanese companies to pursue localization is difficult, as it will require the initial investment.

6.1.3 Continued Technical Support for Local Suppliers

It is imperative for Japanese companies to collaborate with local suppliers in order to continue taking part in the South African market. The South African government also strongly requests technical assistance to local suppliers.

As explained above, Toshiba has experience in supervising UCW and over ten other local suppliers (many are machine-processing companies) when it was awarded the 2002 bid for the Series 19E and 15E electric locomotives to ensure that they would meet the Toshiba standard. For example, it provided technical guidance to Rotacon Engineering and a few other companies in the processing of machinery. Toshiba supervised not only the managing personnel but also train the workers directly.

As explained above, Toshiba stationed as many as 20 engineers in South Africa to transfer technology (design, manufacture, and testing) for two and a half years from 2008 to 2010. It succeeded in raising the technical level to that of the 1980s. Even today, Toshiba still stations two engineers there to continue improving maintenance and technical capabilities.

Recently Toshiba is also providing technical assistance to the British company, VAE, in the manufacture of pinion gear. As part of the agreement for the Series 19E electric locomotives, Toshiba invited TRE staff to Japan for technical training. Having a single company to shoulder the cost of such technical training has become a problem.

Furthermore, even though a Japanese company spent many years in providing technical assistance to local suppliers and even though the local suppliers showed gratitude on a personal level, some of them switched jobs after having acquired the technology. Their sense of belonging to the company is low, which presents a problem to Japanese companies. With a view to localization, Japanese companies shall be even more proactive in taking initiatives to train managers and workers of local companies and at the same time, continue to make appeals to TRANSNET, PRASA, as well as the South African government.

6.1.4 Possible Solutions by Japanese Companies in the Future

Toshiba, the only railway-related manufacturer that has established a foothold in South Africa, has not decided whether to set up its own factory there in the future. However, to minimize investment, it is looking into the options of leasing plants and collaboration with local companies through acquisition.

At that time, public support for business expansion in South Africa and technical support through the utilization of government programs can facilitate the expansion of Japanese companies in South Africa and enhance the probability of winning bids.

These government programs can be used to support Japanese companies: 1) Provide training for workers (dispatch a JICA team of human resources experts to DOT to provide guidance), 2) Offer training to TRANSNET and PRASA in Japan, 3) Invite key government officials to Japan, and 4) Actively utilize overseas loans and investment to support Japanese companies when they set up plants in South Africa.

6.2 Involvement of Other Governments in Related Provinces and Railway Lines

6.2.1 History of Foreign Companies' Entry into South Africa's Railway Sector

In the railway sector, Siemens, Bombardier, and Alstom are known as the "BIG 3." Of the three, an overview of Siemens is given below as an example.

Siemens has operations in 164 countries. It entered South Africa's railway sector in 1974. It employs 1,800 people and has approximately 10% of the railway sector. Siemens' main business in the railway sector is signal. It only delivers domestically and does not export to other countries. When it procures materials from overseas, it generally purchases from its own group companies. Since Siemens has problems with local suppliers in the electric sector, it is offering them technical training.

As mentioned above, 10% of Siemen's business in South Africa is related to railway and the other 90% is in other fields. With economies of scale, its operation in the railway sector can be implemented in a more efficient and effective manner.

In recent years, Siemens, the other "BIG 3," and GE have received orders from South Africa. GE delivered 143 units of diesel locomotives (Class 43) to TRANSNET.

In terms of the delivery of railway-related equipment other than rolling stock, Siemens has delivered signaling equipment to Gauteng province in June 2011 and received a 90-million Euro order to operate the operation control center.

Table 6-2 Delivery of Rolling Stock by Foreign Companies in Recent Years

Delivery date/ Contract year	Vender/ Foreign supplier	Customer	Type of rolling stock /No. of units	Remarks
2003/ －	UCW/ Siemens	PRASA	Series 10M4 electric trains /44 units	Gauteng province
2003/ －	TRE/ Bombardier	PRASA	Series 10M3 electric trains/ 44 units	Western Cape province
2003–2006/ －	TRE/ Alstom	PRASA	Series 10M5 electric train/ －units	KwaZulu-Natal province
After 2006	UCW/ Bombardier	PRASA	Electric trains for Gautrain/ 96 units	Gauteng province
2012/2009–2011 (Note 1)	GE	TRANSNET	Diesel locomotives (CLASS 43) 143 units (100 ＋43 units)	Gauteng province

(Note1) The contracted year for 100 units was 2009, with the option of additional 43 units delivered in December 2011.
Source: Compiled by Study Team

Table 6-3　Quantities of UCW Rolling Stock Manufactured and Delivery Data (1960 onward)

Type of vehicle delivered	No. of units delivered
EMU trainsets	4657 units
Mainline coaches	4579 units
Electric locomotives	2381 units
EMU refurbishment	926 units
Artisan / official coaches	508 units
Wagons	496 units
Industrial diesel locomotives	143 units
Special coaches	85 units
Loco wreck repairs	21 units
—	—
Total	13,796 units

Customer	No. of units delivered	
Spoornet	7660 units	Domestic delivery
PRASA	5583 units	
PVT-SA	229 units	
Taiwan	165 units	
Zimbabwe	132 units	
Malaysia	129 units	
Botswana	48 units	
Benguella	32 units	
Angola	20 units	
Malawi	11 units	
Total	13,796 units	

Source: Compiled by Study Team based on UCW material documents

Table 6-4　No. of Locomotives Manufactured at UCW

Production year	No. of units delivered	Breakdown	
		Type of rolling stock	No. of units
–1992	2,100 units	Series 5E	555 units
		Series 6E1	1,041units
		Series 7E1	165 units
		Series 8ETFR	100 units
		Series 8EImpara	7 units
		Series 9E	31 units
		Series 10E	75 units
		Series 10E2	100 units
		Series 12E	6 units
		Series E100	20 units
1993–2005	127 units	Class38	50 units
		38E（Amcoal）	3 units
		14E1	10 units
		Push Pull	64 units
2006–	154 units	19EWIP	110 units
		15E	44 units
Total	2381 units	—	—

Source: Compiled by Study Team based on UCW material documents

6.2.2 Technical Support Using Government Programs

GE (USA) has strong ties with TRE, which is a rolling stock manufacturer. It is utilizing a government program to provide TRE training in the USA. In addition, GE issues technical certificates to workers who have completed technical training, as was asked by the South African government. The move was welcomed by the South African government. Having a certificate makes it easier for the workers to change jobs. This helps to lower the unemployment rate promoted by the government.

China has also invited TRE employees to visit China to facilitate the winning of bids. According to our interview at the Chinese embassy in South Africa, China is inviting about 150 people every year to receive training in China. They include engineers, technicians, and officials. Short-term training can be 3–4 weeks and long-term training can be as long as 3 months. The 150 trainees are not limited to the railway sector; they are also from agriculture, clothing manufacturing, and other industries. The specific number of trainees from the railway sector is not known. As shown above, government programs are in place to build a close relationship between the two countries on a routine basis.

The Union Carriage & Wagon Company (UCW), which assembles locomotives and refurbishes rolling stock, does not use programs offered by foreign governments for technical training. It has its own in-house technical training.

6.2.3 Examples of Various Initiatives by the Governments and Companies of Other Countries

Siemens, Bombardier, and Alstom have offices in South Africa, not necessarily limited to railway business. It is believed that setting up offices in South Africa can gain the trust of the South African government and help expand the human network in the community.

On the other hand, China has not yet set up offices in South Africa. According to our interview at the Chinese embassy in South Africa, China faces the following issues in terms of conducting business activities in South Africa:

- Companies from advanced countries have already established branch offices/stores in South Africa. It is not as easy for China to establish a new base. Foreign companies need to pay attention to the BEE level, making it important to collaborate with companies of South Africa. It is necessary for China to establish a joint venture business model for the future.
- China excels in selling to overseas. In South Africa, localization, technical transfer, high cost, strikes, and various other issues make business operation challenging.
- The assembly cost in South Africa is very high. The Chinese government needs to negotiate.
- It is necessary to be prepared for the long haul if one is to start a new business in South Africa. It is also necessary to look into government assistance.

China is reluctant to establish offices in South Africa. However, China's early assessment of investment risks, backup financing, and connection with upper level personnel have led to its success in getting orders in recent years.

Tables 6-5 and 6-6 summarize the initiatives taken jointly by foreign companies and South African railway companies.

Table 6-5 Examples of Initiatives by Foreign Companies and South African Railway Companies

Foreign company	South African railway company	Initiative
GE	TRE	・GE and TRE formed a partnership for the locomotive project. Currently 143 units of Series 43 diesel locomotives are being manufactured at TRE under an OEM (Original Equipment Manufacturer) contract. ・GE has contracted several programs at the TRANSNET School of Engineering (SOE). ・GE is utilizing a government program in the USA to provide training to TRE employees.
Alstom	TRE	Alstom and TRE have a partnering relationship.
Siemens	PRASA	Siemens provided education and training to 130 PRASA technical people and 70 operating people when it delivered a new signaling system to PRASA.
Deutsche Bahn (DB)	TFR	DB signed an agreement with TFR in February 2012 for the introduction of a railway safety management system to enhance safety (agreement term 30 months). Four to five DB employees are stationed at the TFR office.

Source: Compiled by Study Team

Table 6-6 Examples of Collaboration between South African Companies and Foreign Companies (at bidding)

No.	South African company	Main products	Contents of collaboration
1	Donkin Fans	Blower	STADDLER (UK) has made contact for the bidding of a PRASA project.
2	Siyahamba Engineering (Pty) Ltd	Car doors and windows	Korea has made contact.
3	Ansys Limited	Train position tracking system	Participated in the bidding of Gautrain as a GE subcontractor.
4	SIMS (Stimera Infrastructure Management Services)	Track/ Electricity/ training	・Formed consortium with Bombardier and others for the bidding of the Durban signal upgrade project. ・Have been contacted by Australia and a Chinese company (CRM=China Railway Material Company).
5	CSR (China South Rail)	－	CSR and TRE succeeded in winning the bid for the procurement of TRANSNET rolling stock.
6	CSR (China South Rail)	－	CSR formed a consortium with a local company Wictra Holdings (Pty) Ltd to tender bid for the PRASA procurement of rolling stock. Wictra is a company that refurbishes rolling stock for PRASA.

Source: Compiled by Study Team

Table 6-7 Examples of Collaboration between South African Companies and Foreign Companies (on regular basis)

South African company	Main products	Contents of collaboration
OTD (Overhead Track Developments) (Note 1)	Siemens	When OTD procures carbon contact strips from overseas, the procurement is through Siemens.
Siyahamba Engineering (Pty) Ltd	GE	Export small quantity (1%) to the USA and Taiwan through GE
Ansys Limited	GE	Partnered with GE for the automation of marshalling yards
Naledi Rail Engineering (Note 2)	Bombardier・Alstom	French employees with previous Alstom and Bombardier experience have joined the management of Naledi Rail Engineering and are carrying out business reform.

（Note 1） Pantograph manufacturer for railway use

（Note 2） Refurbishment and repair of passenger EMU

Source: Compiled by Study Team

6.2.4 Other Support Activities

Financial assistance from the world to South Africa's railway sector is as shown in Table 6-8. In the period from 1951 to 1961, the World Bank was the only donor that provided financial assistance. In the forty years afterwards, there was no financial assistance from the world to the railway sector in South Africa. In 2002 and 2007, the USA extended grant aid of approximately 50-60 million USD. Later on, the African Development Bank provided financial assistance in excess of 400 million USD.

Table 6-8 Financial Assistance from the World to South Africa's Railway Sector

Year	Donor	Contents of assistance	Commitment (USD)
2010	African Development Bank (AFDB)	Transnet Limited	413,899,742
2007	United States	New Spoornet Locomotives - Training	515,609
2002	United States	INTEGRATED RAIL FREIGHT	594,974
1961	World Bank	Expansion of Transport Facilities Project	84,835,978
1959	World Bank	Railway Improvement Project	89,463,395
1958	World Bank	Railway Improvement Project	192,809,040
1957	World Bank	Railway Improvement Project	192,809,040
1955	World Bank	Transportation Project	194,351,513
1953	World Bank	Transportation Project	231,370,848
1951	World Bank	Transportation Project	154,247,232

Source: AIDDATA
（http://www.aiddata.org/content/index/data-search#c6de4b7e967b5ae3452af6a5fd44a027）

[Reference] Bidding from FY 2012 onward

Table 6-9 shows the bidding projects from FY 2012 onward.

Besides bidding for the TRANSNET "95 units of electric locomotive for general freight business" and the first 10 years of the PRASA 20-year procurement of "7,224 units of electric

trains," there are also bids for the TRANSNET "465 units of electric locomotive for general freight business" and "599 units of electric locomotive for the general freight business" in February 2013. For the "95 units of electric locomotive for the general freight business," CSR Zhuzhou in China has been awarded the order.

Table 6-9 Bidding Projects from FY 2012 Onward

Delivery date/ Contract year (Note 1)	Type of rolling stock/quantity	Customer	Remarks
2013/2012	95 units of electric locomotive	TRANSNET	・For general freight business (GFB) ・CSR and TRE have jointly been awarded the project. ・UCW + Mitsui Group failed in the screening process before bidding.
2015/2012	7,224 units of electric train/20 years (10 years/bid x 2 bids)	PRASA	・For Metrorail use ・Closed bid on September 30, 2012 ・123 billion ZAR (14.93 billion USD) ・Apart from the above, 14.5 billion ZAR for the development of infrastructure and railway depots. ・Gibela Rail Transportation (consortium of Alstom and the local company Actom) was awarded the first refusal right. The other six bidders are as follows: 1. Bombardier 2. Construcciones y Auxiliar de Ferrocarriles (CAF, Spain) 3. CNR 4. CSR 5. Dudula Rail (consortium of ABB SA and Stadler (Switzerland)) 6. CSR/Wictra (consortium of CSR and local company Wictra)
－/2012	465 units of diesel locomotive	TRANSNET	・For general freight business (GFB) ・Bid to close in February 2013
－/2012	599 units of electric locomotives	TRANSNET	・For general freight business (GFB) ・Bid to close in February 2013
TBD/TBD	112 units of Series 19E electric locomotives	TRANSNET	For Coal Line use
TBD/TBD	23 units of Series 15E electric locomotives	TRANSNET	For Iron Ore Line use

Source: Compiled by Study Team

Chapter 7

Roadmap

for the Modernization of the Railway Sector

Chapter 7 Roadmap for the Modernization of the Railway Sector

7.1 Review Appropriate Technologies

Modernizing railway entails not just the use of new facilities and new rolling stock. Only when the railway has become appealing to users as reliable and desirable can it attract many users and can its operation be sustainable. The goals that shall be targeted for the modernization of railway can be demonstrated specifically with the following elements:

“Safety”: It is to improve the safety of transport, that is, to establish and maintain a system that will make it less likely for collision or derailment that causes personal injury and property damage to occur.

“Speediness”: It is to achieve speediness in order to gain an edge over the other transportation modes. This includes not only high speed but also high frequency to reduce waiting time and appropriate fare paid by the passengers for the required travel time.

“Punctuality”: It is to gain the trust of passengers and shippers by ensuring the accuracy of arrival/delivery time.

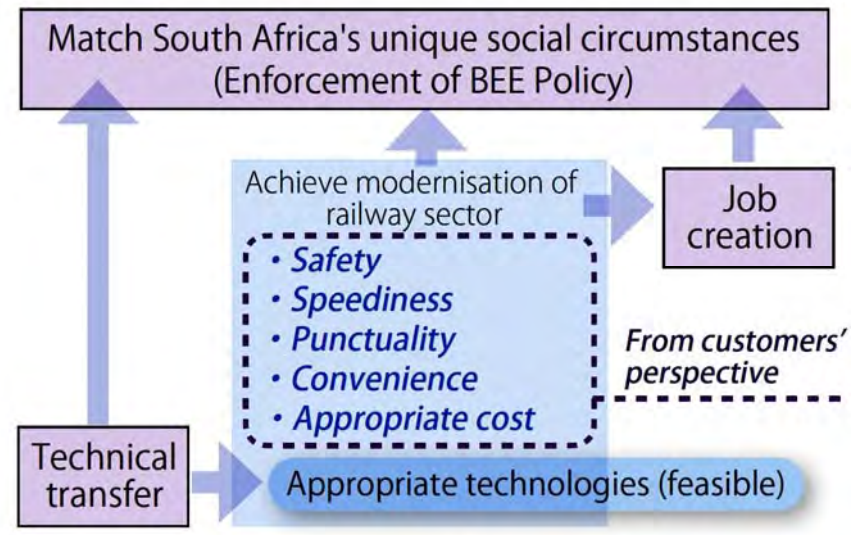
“Convenience”: It is to make it easy and convenient for users so that they want to use the service.

“Appropriate cost”: It is to reduce the cost of maintenance and management to achieve cost-effectiveness. The fare shall be within a range affordable to the users.

In order to modernize the railway sector mentioned above, the railway sector must be able to accept the new technologies to be introduced. The technologies must also be able to deliver adequately the anticipated effects. They are what the Study Team refers to as “appropriate technologies” for the modernization of the railway sector in South Africa.

A characteristic of South Africa is that the appropriate technologies being considered must match the unique social circumstances of South Africa and contribute to the advancement of policies. An important prerequisite is to help broaden the scope of the BEE Act through technical transfer and job creation.

Figure 7-1 illustrates the concept of appropriate technologies.



Source: Compiled by Study Team

Figure 7-1 Concept of Appropriate Technologies

7.1.1 Rolling Stock

As can be seen in the Iron Ore Line and Coal Line, the technical level of freight trains in South Africa boasts one of the world's high standards in terms of mass transport by heavyweight freight train.

However, the general cargo train is still using mainly old vacuum brake, raising concern about safety. It is also true that train cars tend to breakdown easily due to the aging of rolling stock. However, the fault data of rolling stock are used only for the maintenance of the rolling stock. The concept of preventive maintenance, which is to analyze the causes and carry out the necessary maintenance before the rolling stock breaks down, has not been adopted.

There have been no new passenger cars built for many years. The situation is the same for freight cars with regard to the brake system and maintenance.

It is by combining the technology of a mass transport system of the world's leading technology and maintenance technology to enable it to operate regularly for a long time that will realize, for the first time, effective use of the large number of new locomotives and new-model trains to be launched in the future, as well as safe and efficient transportation.

It will take a long time to improve maintenance to the extent that it will bring about the necessary efficiency for achieving appropriate cost and trust in the punctuality and speediness of the transport. To that end, the Japanese experience of making improvement to enhance maintenance efficiency accumulated over many years will be useful. With the advancement of rolling stock technology, Japan has been working on extending the maintenance cycle and simplifying its contents while preserving the level of reliability.

In 1955, the former Japanese National Railways had to perform a semi-overhaul of electric trains every year and a full inspection every two years. In 1999, the cycles were extended to four and eight years, respectively. This is attributable not only to improvement in reliability and durability of the equipment mounted onboard the vehicle but also to progress in maintenance research that improves the diagnostic techniques and maintenance technology, thus enhancing the accuracy of predictions about the wear and degradation of each component part.

In this way, the establishment of highly reliable and efficient maintenance technology is imperative to ensuring successful launch of the new-model rolling stock in the future.

It is to be noted that the market size of rolling stock manufacturing for the next 10 years is estimated to exceed 60–70 billion ZAR, not counting the current bids. The estimate includes the Phase-II procurement of approximately 3,600 units of commuter trains by PRASA and increase in the reserve of locomotives to meet the anticipated increase in freight demand in the future.

7.1.2 Signaling and Telecommunications

In our review of appropriate technologies for South Africa, the Study Team considers signaling and telecommunications an indispensable and realistic means for achieving the goals of the mid- and long-term plans of TRANSNET and PRASA at this time.

By updating the aging facilities of Metrorail, PRASA aims to improve safety, reliability, and operability; ensure service punctuality; and increase transport capacity by shortening headways. From our review of specific measures, the Study Team identifies the following three points that shall be pursued in order to help realize the goals of modernization.

(1) Introduction of Automatic Train Protection System (ATP)

PRASA aims to achieve a headway of 2 minutes and 30 seconds for Metrorail in the future. At the time when the new rolling stock is introduced, if the headway is set at 2 minutes 30 seconds, it is necessary to introduce the Automatic Train Protection System, on the assumption that

operation error will occur, rather than merely relying on the control of the driver to ensure safe operation.

(2) Introduction of Traffic Control System

If the trains are delayed due to an accident, the deployment of trains has changed, or the train operation has been disrupted, it is necessary to have a traffic control system that can organize the operation of trains and allow the dispatcher to change the timetable from the dispatcher's desk. In the development plans, if train operation is disrupted, a dispatcher still has to set the routes manually. The communication between the dispatcher and the station staff on how to handle the train operation still relies on the dispatcher's telephone. Ensuring service punctuality is one of the development plans. It is essential to find the right balance between reducing the workload of the dispatchers and streamlining operation with the use of a traffic control system.

(3) Enhancing Capability for Managing Maintenance

TRANSNET views the transport of heavy freight as its business base in the mid- to long-term development plan. In order to ensure stable earnings, it aims to increase transport capacity and ensure stable transport.

Rather than placing emphasis on regular maintenance for its infrastructure facilities, TRANSNET puts emphasis on stopping all its freight transport during a certain period of the year to contract large-scale repairs. Therefore, its daily emphasis is on the detection and restoration of broken track, signal failure, and other such problems. For this purpose, TRANSNET is focusing on the development and improvement of a Facilities Monitoring System that can identify immediately and efficiently identify the situation in order to avoid transport disruption caused by failures and loss in revenue.

However, they are nevertheless measures for improving efficiency in identifying failures from a hardware perspective. It is necessary to strengthen education and training, and find ways to preserve the maintenance technology for repair and adjustment when there are failures. In this respect, PRASA is lagging behind both in terms of hardware and software. It requires the same response.

For the implementation of the above measures to improve facilities, the market size of PRASA is estimated to be 15 billion ZAR, including some of the signaling and telecommunications facilities. On the other hand, the market size of TRANSNET for some of the main freight transport sections is estimated to be 25 billion ZAR. Together they have a market size of approximately 40 billion ZAR.

7.1.3 Electric Power

As also set forth in the TRANSNET plan, increasing transport capacity is the main theme for the modernization of the railway sector. The following technical issues can be identified from the current state of the railway sector in South Africa:

- Measures to address aging facilities
- Measures to increase the frequency of train operation
- Measures to enhance the train's loading capacity
- Measures to increase speed

In relation to these big topics, the three items below are related to power substations and overhead contact lines.

The railway sector in South Africa has been established based on the European technical standards. In the DC electrified sections, in particular, since Japan has made little advancement

in the 3kV DC technology, it will be difficult to make inroads into this field. In the AC field as well, while Japan has to use complicated feeding transformers with internal wiring, such as the Scott connected transformer and modified wood-bridge connected transformer, South Africa uses a simple configuration that connects a single-phase transformer to the three-phase transmission line. The differences in installation and other environmental conditions are evident, making entry into the main circuit system difficult. Based on this, although it is possible to enter into the areas of maintenance technology or protection technology, the scale will be small.

(1) Upgrade and Improve Facilities

Over forty years have passed since the installation of many railway electrical facilities in South Africa between the second half of the 1960s to the 1980s. The facilities are showing signs of aging.

The life cycle for AC circuit breaker, transformer, rectifier, high-speed DC circuit breaker, and other main equipment at substations has been designated to be 50 years. The facilities are approaching overhaul or replacement. They are being handled by the manufacturers.

With increase in transport capacity, it has become necessary to reexamine the substation capacity. Using the Coal Line as an example, the Study Team conducted a brief review. The Coal Line uses 25kV AC electrification. It has a total length of 450 km. The interval between substations is about 20 km on the average. Freight trains of 2.4 km in length operate at a maximum speed of 80 km/h and an average speed of 60km/h. There are 16 trains per day one-way and the whole trip takes 10 hours. In this case, the train interval is 90 minutes (24 hours/16 trains). Since it takes a train 20 minutes to pass a substation, each substation runs for 20 minutes at a 90-minute cycle and stops for 70 minutes. If the transport capacity is double of the current level, (TRANSNET plans a 1.5-time increase), then the substation will have a 45-minute cycle, running for 20 minutes and stopping for 25 minutes. Although the Coal Line is a double-track line, the train timetable is scheduled in such a way as to allow only one train to operate in one substation section. Therefore, it is not necessary to increase the capacity of the substations.

(2) Strengthen Maintenance and Inspection

With increase in transport capacity, if the number of trains increases and the speed is raised, the operating hours of the equipment will naturally increase. The wear on the contact wire will become faster, making it important to manage the wear and tear of the overhead contact line. The electric locomotives for freight transport that have 25kV-AC and 50kV-AC electrification use pantograph with carbon contact strip but the 3kV-DC Metrorail trains use pantograph with copper contact strip, which makes the wear on contact wire even faster. Therefore, it will be effective to strengthen maintenance and inspection by introducing technology to manage the wear and tear of the contact wire.

(3) Speed up Restoration for Failures and Accidents

In the past one year and two months from November 2010 to January 2012, about 100 cases of accidents related to electric power substations have interfered with train operations. About one-third of them were fault accidents that occurred in the substations or along the railway lines. In addition, theft of the contact wire along the railway lines occurs frequently. Compared to the failures at substations, it often takes longer time to locate failures and accidents at the wayside. In addition, most of the wayside failures and accidents are ground faults and short-circuit faults. Therefore, it will be effective to install at each substation a fault locator to identify the point of failure from the fault current in order to accelerate recovery from accidents and failures.

7.1.4 Civil Engineering

The TRANSNET 7-year plan aims to increase the freight transport volume in the next seven years to approximately 1.8 times of the current level. Since increase of transport volume will exert more burdens on the track, track maintenance will become increasingly important in the future. In addition, the PRASA modernization project aims to improve the safety of passenger transport by introducing new rolling stock and modernizing facilities. Track maintenance also plays an extremely vital role in helping to improve safety. However, as mentioned in Chapter 4, both TRANSNET and PRASA do not have sufficient track maintenance technology. It is essential to enhance the level of technical capabilities in track maintenance. At the same time, it will be important to reduce track maintenance cost by introducing technologies to reduce track maintenance works and adopting highly durable track materials in the future.

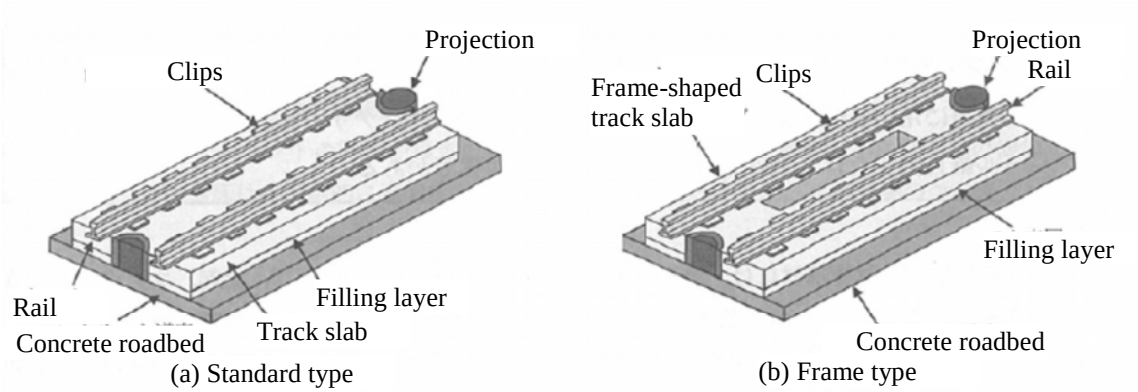
Although details of the TRANSNET 7-year investment plan have not been revealed, an investment of 71.1 billion ZAR is planned for track facilities and the investment in track materials is assumed to exceed the levels up until now. The market size for track facilities in the next 10 years is estimated to be about 50 billion ZAR.

On the other hand, the TRANSNET 7-year investment plan will conduct studies for the Swaziland rail link and Waterberg new line but it does not have any concrete construction plan yet. There is also currently no planned construction of new lines. PRASA is working on station improvement and extension of existing lines. It does not have any specific plans for constructing new lines at this time. This suggests that the possibility of Japanese companies entering the field of civil engineering is small.

The following can be considered appropriate technologies for promoting modernization of the railway sector in South Africa:

(1) Low-maintenance Track（slab track)

Slab track is one of the low-maintenance tracks. The ballastless track supports the rail and track slab with a filling layer, slab projection, and concrete roadbed. Figure 7-2 is a schematic view of the slab track. Compared to the ballast track, the initial construction cost of slab track is higher but the maintenance cost is low due to little need for maintenance afterwards.



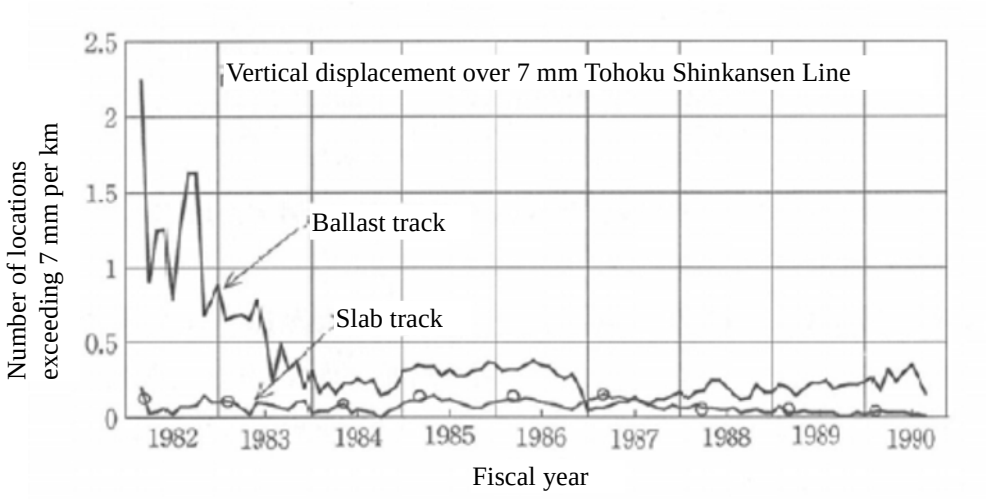
Source: “Standards and Explanations of Railway Structures: Track Structures,” supervised by the Railway Bureau of the Ministry of Land, Infrastructure, Transport and Tourism and edited by Railway Technical Research Institute, April 2012

Figure 7-2 Schematic View of Slab Track

1) Status of Maintenance

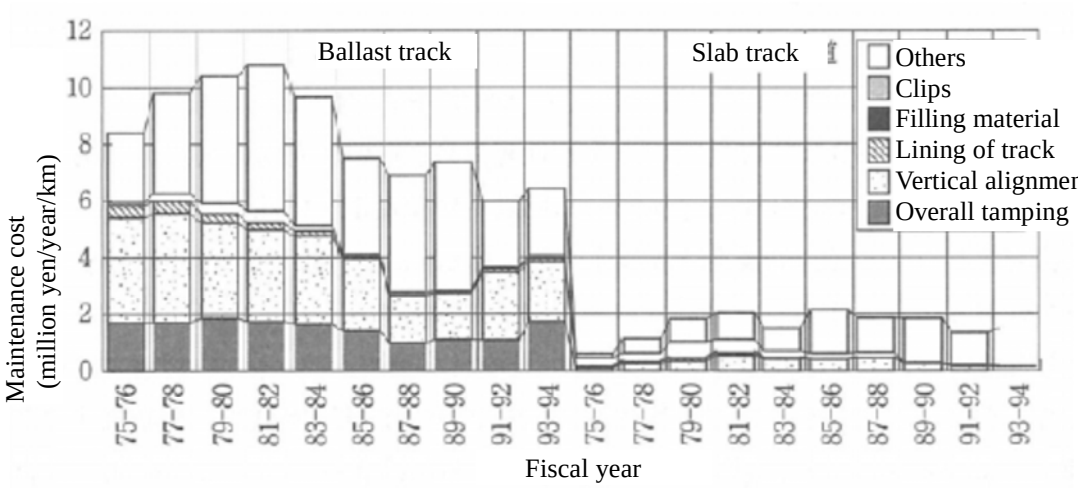
Figure 7-3 shows the changes in track displacement between the ballast track (the data of both were taken from viaducts and tunnels) and slab track on the Tohoku Shinkansen Line. The slab

track maintains good track condition. Figure 7-4 shows the changes in maintenance cost for one section of the Sanyo Shinkansen Line. The maintenance cost of slab track is about one-fourth of that of the ballast track.



Source: "Standards and Explanations of Railway Structures: Track Structures," supervised by the Railway Bureau of the Ministry of Land, Infrastructure, Transport and Tourism and edited by Railway Technical Research Institute, April 2012

Figure 7-3 Changes in Track Displacement at the Tohoku Shinkansen Line



Source: "Standards and Explanations of Railway Structures: Track Structures," supervised by the Railway Bureau of the Ministry of Land, Infrastructure, Transport and Tourism and edited by Railway Technical Research Institute, April 2012

Figure 7-4 Changes in the Maintenance Cost of Sanyo Shinkansen Line

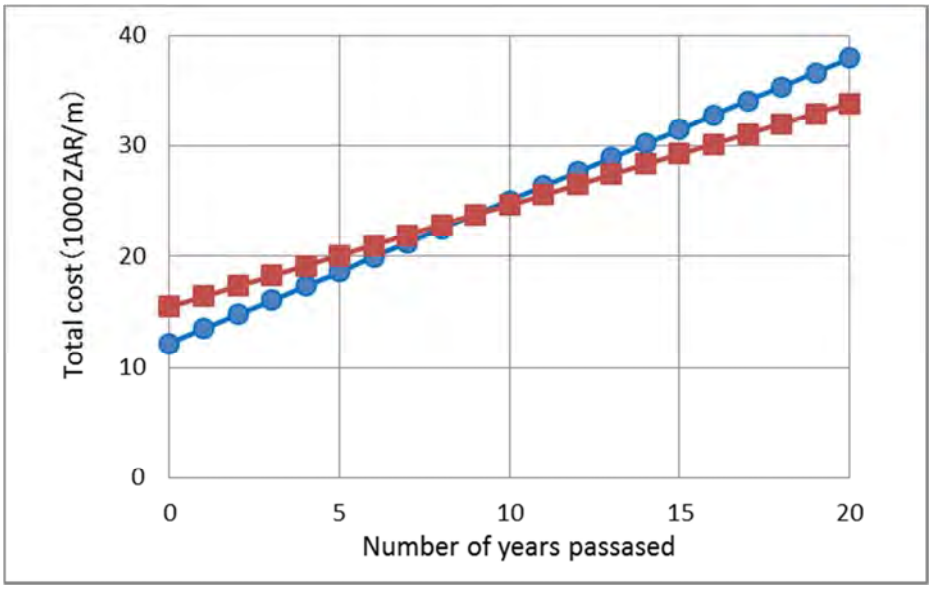
2) Economic Efficiency

Table 7-1 and Figure 7-5 is an example of calculation comparing laying ballast track vs. slab track in tunnels and viaducts. According to Table 7-1, the initial construction cost of slab track is more expensive than the ballast track. However, since the annual expenses of slab track are lower, the total cost of slab track will be lower in about 9 years. Including the initial construction cost and maintenance cost, the life-cycle cost of slab track is more economical.

Table 7-1　Comparing the Economic Efficiency of Ballast Track and Slab Track for Shinkansen (on viaducts and in tunnels)

	Slab track A	Ballast track B	Comparison A－B
Construction cost	15,500 ZAR/m	12,220 ZAR/m	3,280 ZAR/m
Annual expenses	917 ZAR/m	1,286 ZAR/m	－369 ZAR/m

Source: “Standards and Explanations of Railway Structures: Track Structures,” supervised by the Railway Bureau of the Ministry of Land, Infrastructure, Transport and Tourism and edited by Railway Technical Research Institute, April 2012



Source: “Standards and Explanations of Railway Structures: Track Structures,” supervised by the Railway Bureau of the Ministry of Land, Infrastructure, Transport and Tourism and edited by Railway Technical Research Institute, April 2012

Figure 7-5　Economic Comparison of Ballast Track and Slab Track (on viaducts and in tunnels)

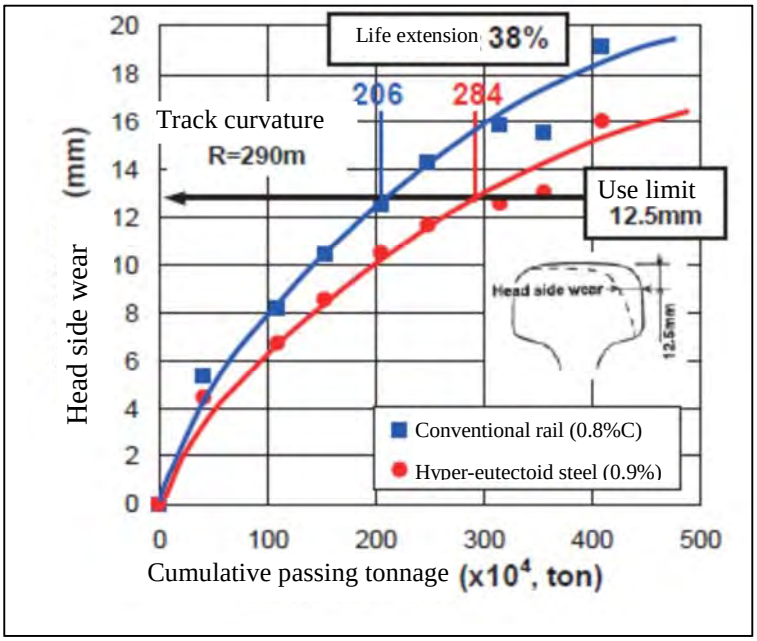
(2) Compound Sleeper

Compound sleepers use fiber reinforced foamed urethane (FFU) as material. (FFU is a kind of foam plastic reinforced with glass fiber: rigid urethane resin reinforced with glass fiber.) The weight is similar to wooden sleeper. It is easy to process, easy to construct, and has the same durability as prestressed concrete (PC) sleepers. Compound sleepers have been used for the commercial railway lines in Japan for about 25 years. They maintained good physical properties, with no deterioration or corrosion. In addition, the bending fatigue property of compound sleeper is estimated to have a service life of over 50 years.

(3) Rail

Head Hardened rail (HH rail) has been manufactured by treating the entire surface of the railhead with heat. Because it has high resistance against wear and fatigue, it is used widely in Japan and abroad for conditions, such as curved sections and heavy axle load. Furthermore, HE rail, which has higher hardness and improved abrasion resistance compared with the conventional HH rail, has been developed in recent years. Figure 7-6 shows the abrasion

resistance of HE rail. It has the world's highest level of abrasion resistance and resistance to damage caused by interior-originating fatigue. Use of the highly abrasion resistant HE rail for the curved sections of high-axle load lines, such as the Coal Line and the Iron Ore Line, is beneficial.



Source: Nippon Steel Corporation material

Figure 7-6 Abrasion Resistance of HE Rail

7.1.5 Automatic Fare Collection

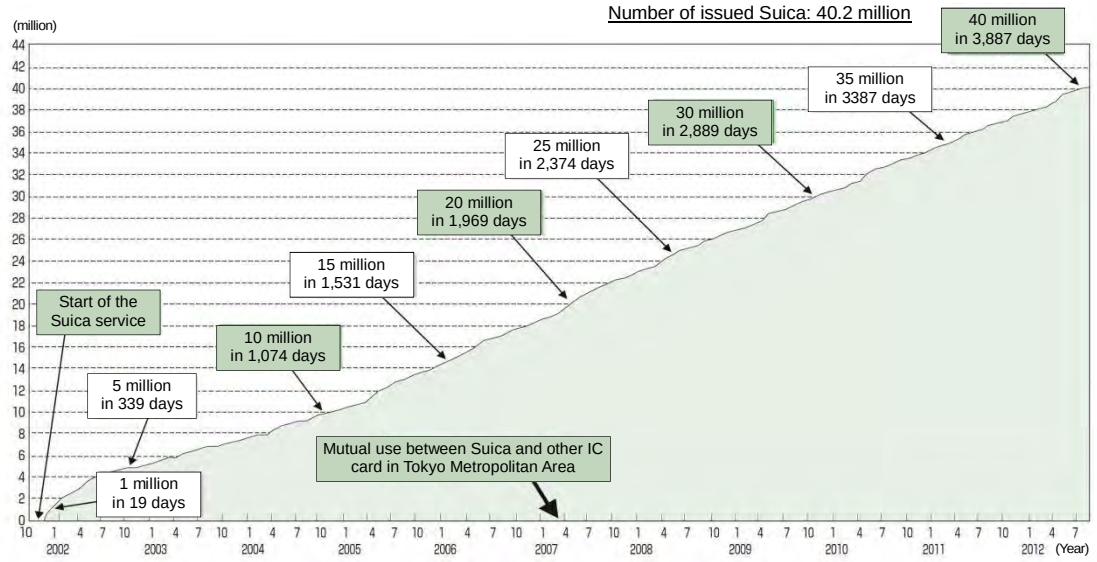
For a railway to have stable operation, it is necessary to entice more people to use railway in order to secure revenue. To this end, in addition to the modernization of rolling stock, signals, and tracks described so far, it is effective to make the system easily accessible from the point of view of the users.

In Japan, JR East introduced the Super Urban Intelligent CArd (Suica) in 2001. This automatic fare collection (AFC) system uses IC card instead of paper tickets. The IC card ticket system has already been put to practical use by Gautrain in South Africa. However, Suica not only has the function of a train ticket but also a variety of other functions. They are as follows:

- The Suica IC card can be used not only for JR East but also for other railway companies and bus routes using the same system. The IC cards issued by other companies (PASMO, IKOCA, etc.) can also be used at JR East.
- The amount charged to the IC card can be used not only for riding trains but also for shopping at the stations and in the city.
- Some Suica is also equipped with the credit card function. In this case, when the amount to Suica runs low, it will automatically charge a preset amount.
- An IC chip can be inserted into a smart phone to give Suica functions to the phone.

Due to the features described above, there is no need to purchase a ticket every time when using a transportation mode, thus greatly increasing the convenience for users. Moreover, from the standpoint of the railway operator, it is possible to reduce the number of ticket machines, lower maintenance cost, and utilize the high-traffic spaces in the station for commercial use effectively. Figure 7-7 shows the number of Suica issued. Due to the convenience of Suica, its use is rising every year.

(As of 31 Jul. 2012)



Source: "Company Directory 2012-2013," JR East, November 2012

Figure 7-7 Changes in the Number of Suica Issued

In South Africa as well, if a new urban transport system combining public transport modes such as commuter railways and buses is built in the future, introducing an automatic fare collection system that is convenient for the users will be effective in promoting use of the transport modes.

If the AFC system is introduced to the Metrorail network, the market size is estimated to be approximately 50 billion yen.

7.1.6 Market Sizes of Various Sub-sectors

Table 7-2 shows the market size of each railway sub-sector projected in the future and the possibility of entry by Japanese companies. The market sizes are the estimated amounts of projects with investment plans or prospect of investment for the next 10 years, excluding those that have already concluded agreements or are expected to conclude agreements.

Table 7-2 Market Sizes of Various Sub-sectors

Sub-sector	Estimated market size	Possibility of entry by Japanese companies
Rolling stock	60–70 billion ZAR	High
Signaling and telecommunications	40 billion ZAR	Medium
Electric power	Small scale	Low
Civil engineering	No construction of new lines	nothing
Track	50 billion ZAR	High
Automatic fare collection	5 billion ZAR	High

Source: Compiled by Study Team

7.2 Comparing the Technologies of Japan and Other Countries

The Japanese railway technology has been developed along two major axes: high frequency commuter transport in cities and high-speed railway, that is, high-capacity/high-speed transport by shinkansen. The pursuit of speediness and punctuality through these developments results in

the advancement of operational technologies, including an optimal signal system for each form of transport. In addition, improvement to the power system of rolling stock and lightweight car body has reduced the energy consumption of trains, minimized the scale in the expansion of power facilities, and reduced the cost of track maintenance. While facing competition from other transportation modes, such as airplane and automobile, the intercity railways and freight transport continue to seek ways to increase speed and lower cost to levels that are commensurate with their business scales.

In any case, ensuring the safety of transport is the highest priority. In addition to introducing new facilities, Japan continues to devote efforts to appropriate maintenance in order to ensure safety and clarify the quantitative limit in the use of each element. This has led to the reduction of operating costs.

With regard to rolling stock, signal, track, and AFC, the four areas that are expected to increase in market sizes, we describe below the characteristics of Japanese technologies from the perspective of comparing with the technologies of other countries.

7.2.1 Rolling Stock

(1) Freight

A unique feature of South Africa is that it transports high volume of freight efficiently on the Iron Ore Line and Coal Line, which allow heavy axle load. Since Japanese rolling stock manufacturers have experience delivering electric locomotives, such as the Series 19E with axle load of 30 tons, to South Africa for many years, the Study Team believes that they have earned certain trust. Moreover, a container cargo train that can operate at a maximum speed of 130km/h, which is a technology unique to Japan, has been put into practical use. The technology can meet the needs of high speed.

(2) Passenger

Although there are also passenger trains hauled by locomotives in Japan, train cars using a distributed traction system, such as electric and diesel cars, are widely used. Most of the trains, not only the urban railways but also the intercity trains, use a distributed traction system. Shinkansen, the first high-speed railway in the world, has been using EMUs for 48 years, since it launched service.

The characteristics of the distributed traction system are as follows:

1) The distributed traction system has many power cars. Since it is easy to have high power output throughout the trainset, the train can run on slopes at high speed. Even after slowing down to the specified speed limit at the curves, it can accelerate quickly, thus shortening travel time.

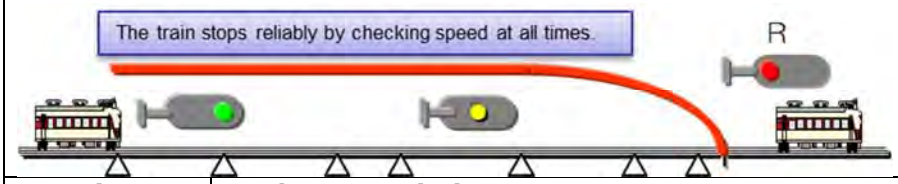
2) The trainset can be shortened in accordance with the demand, thus minimizing waste. In the case of Japan, the limited express train is a typical intercity train. It can be as short as two train cars. In contrast, a train hauled by a locomotive has to use the same locomotive no matter how short the train is, resulting in a lot of waste.

Since trains with a distributed traction system have more equipment, it is often considered a disadvantage from the perspective of maintenance. However, compared to the past, the amount of maintenance today is greatly reduced. The reasons are manifold. The AC induction motor can now be used as the main motor. Different from the DC motor in the past, an AC induction motor does not have carbon brush, which is a wear component that requires frequent replacement and regular cleaning inside the electric motor. Moreover, use of an electronic device for the control circuit has eliminated mechanical contact of the electrical circuit and cam shaft (such as relays), which are prone to fault.

In South Africa, the demand for intercity passenger rail is very little at this time. Introducing rolling stock with a distributed traction system can provide both the transport capacity and frequency commensurate with the demand. In addition, use of EMUs for intercity passenger transport will enable joint maintenance with Metrorail, which uses EMUs. Consequently, it is highly possible to increase operational efficiency by standardizing and sharing car depots, maintenance personnel, and component parts.

7.2.2 Signaling and Telecommunications

The above-mentioned appropriate technology of automatic train protection (ATP) mentioned in 7.1.2 (1) can be considered a train control system. It has a European system and a Japanese system. A comparison between the two is shown in Figure 7-8. Their functional specifications and performance are essentially equivalent. While it is necessary to apply the user specifications and environmental conditions of South Africa, it is especially necessary to be competitive in price, in addition to the performance of the system.

Train control system	Comparison of European system and Japanese system	
European system ETCS Level 1		
	Train detection	Track circuit, axle detector, etc.
	Transmission of information	Eurobalise or loop line (from ground to train)
	Traffic control	Ground signal
Japanese system ATS-P	ETCS Level 1 is equivalent to the functional performance of ATS-P	
	Train detection	Mainly track circuit, axle detector (backup)
	Transmission of information	Transponder (ground to train)
	Traffic control	Ground signaling system or onboard signaling system

Source: Compiled by Study Team

Figure 7-8 Comparing the European and Japanese systems of Train Control System

In comparing the European system and Japanese system of traffic control, there is no difference in the performance of basic functions, such as traffic control, rescheduling of timetable when there is disruption to train operation.

Rather, with developed and improved functions unique to the Japanese system, the Japanese system has functions that can support regulated train operation due to earthquake, rain, wind, etc.; secure interval for maintenance work in a high-density timetable environment, and prevent trains from entering into closed sections.

Railway operators in South Africa showed strong interest in the infrastructure monitoring system, eyeing especially a certain part of the European Supervisory Control Data Acquisition (SCADA) system. The Japanese system offers a total system that not only monitors the conditions of infrastructure facilities but also integrates ledger management, maintenance data management, and repair plans. When offering education and training in the future with the objective to provide technology for the maintenance of new facilities, rather than merely transferring technology for the hardware, it is important to also transfer the technology (software) for managing maintenance that addresses the situation in South Africa.

7.2.3 Track

(1) Low-maintenance Track (Slab Track)

Slab track is a technology developed in Japan. It has been used for high-speed railway (shinkansen) sections and elevated lines since the Sanyo Shinkansen. Although it requires sophisticated construction technology, if it is constructed as designed, the amount of track subsidence is smaller than that of the ballast track. The slab track can maintain very good track condition. As examples of slab tracks in other countries, RHEDA track and Bagel track have been developed in Germany. Both tracks have high precision that are comparable to the slab track in Japan and are designed for high-speed operation.

There is no published data comparing the economic efficiency of these slab tracks. However, it is said that the German Bagel track is more expensive and the German RHEDA track is less expensive than the slab track in Japan.

A characteristic of the Japanese slab track is that when there is large deformation caused by earthquake or other reasons, it is possible to make partial repair by replacing the slab track at every 5m. The German slab tracks have a continuous structure. Partial repair of the slab track is difficult.

China does not have any experience in slab track. It adopted the slab track technology of Japan and the slab track (RHEDA track and bagel track) technology of Germany for constructing the high-speed railway. Including the sections currently under construction, China has adopted the Japanese slab track for approximately 1,500 km. When introducing the Japanese slab track, Japanese construction companies formed joint ventures with Chinese construction companies to transfer technologies, including manufacturing technology and construction technology.

On the other hand, the slab track (T-Track) developed in South Africa is designed for standard gauge (1435mm) and can operate at 80 km/h with axle load of 30 tons. Although the slab track has received technical certification from TRANSNET, the technology cannot handle high-speed operation yet.

(2) Compound Sleeper

Compound sleeper using FFU material is a technology developed by Japanese companies. In the late 1970s and early 1980s, track development and track-laying tests were conducted in Japan. In 1987, it made its debut as track sleeper. Compound sleeper is lightweight, easy to construct, and more durable than the wooden sleeper is. Because of these characteristics, it is increasingly being used for bridge sections and branch sections where it is relatively difficult to replace sleepers.

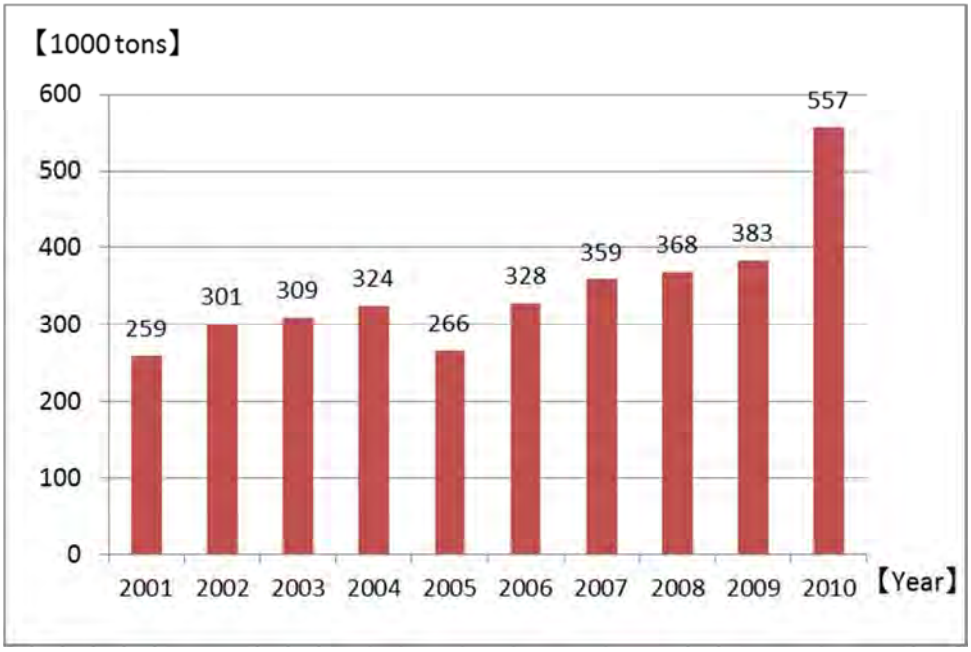
It has also been introduced to other countries. In Europe, it was adopted for the Austrian railways in 2004 and German railways in 2008. Increase in the use of compound sleepers is expected in the future. Compound sleeper has been used for the Taiwan High Speed Rail and Guangzhou Metro in China. As China expands its railway, the demand is expected to rise. Plants have been set up for local production. Compound sleeper is highly regarded as a uniquely Japanese technology.

(3) Rail

Figure 7-9 shows the changes in the export volume of Japanese rail from 2001 to 2010. The rail export volume has been increasing in recent years. It has about doubled in the past decade. The main export destinations are United States, Canada, Brazil, Australia, and Russia. The export volume rose sharply in FY 2010 compared to the previous fiscal year. This was due to an increase in the volume of exports to emerging economies, such as Russia, countries in Latin America, and Saudi Arabia. Japanese rail is exported to the United States and Canada for the

freight railways in North America, to Brazil and Australia for mining railways, and to Russian for freight railways. The Japanese rail is primarily used under the condition of high axle load.

Most of the rails produced in Japan are exported. The production volume of Japanese rail in FY 2010 was 630,000 tons. Approximately 90%, an equivalent of 557,000 tons, were exported. Although Japanese rail production only accounts for 6.7% share in the world (2010), it is regarded highly as a product with excellent durability and resistance against wear and internal fatigue.



Source: Compiled by Study Team

Figure 7-9 Changes in the Export Volume of Japanese Rail

7.2.4 Automatic Fare Collection

The Type A and Type C shown in Table 7-3 are the main specifications of IC cards used for tickets. Type C is a specification based on Japanese technology. The system is suitable especially for commuter railways that have high concentration of passengers within a short time.

Table 7-3 Characteristics of IC Cards by Type

	Merits	Demerits
Type A	・ Low cost ・ Widely known in the world as "Mifare"	・ Protocol (note) not designed for high-speed processing
Type B	・ Has high transmission speed	・ Protocol not designed for high-speed processing
Type C	・ High-speed protocol ・ Large information volume ・ Easy to operate	・ High cost initially but it has come down

(Note) Protocol: Rules required for communication between computers. Conventions such as communication speed, communication method, error checking, etc.

Source: "Study on the Introduction of IC Card for Transportation Use in East Asia," Policy Research Institute for Land, Infrastructure, Transport and Tourism under the Ministry of Land, Infrastructure, Transport and Tourism, July 2005

7.3 Feasibility of Localizing the Production Processes of Rolling Stock and Equipment of Japanese Companies

7.3.1 Rolling Stock

Bidding for the first half of the PRASA 20-year procurement plan of EMUs that totals 3,600 units for 10 years has been completed. Gibela Rail Transport Consortium, formed by Alstom and a local company Actom, was awarded the first refusal right. According to report, the bidders did not include any Japanese rolling stock manufacturers. Japanese companies will have to wait until the 3,600 units for the second half of the plan to participate in any large-scale investment in the future.

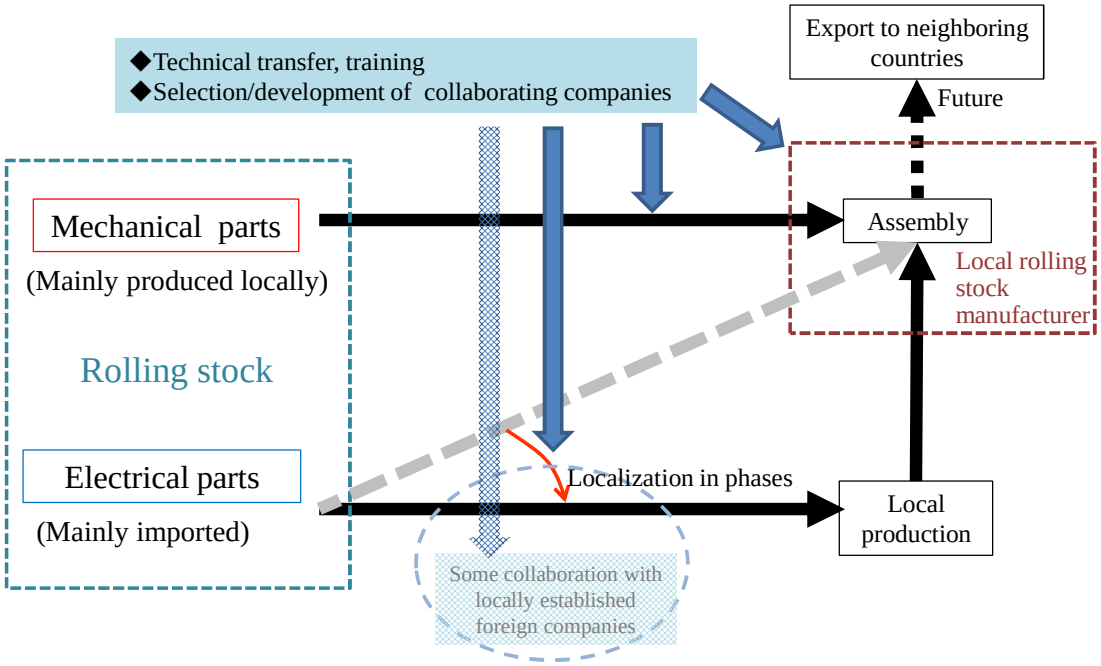
The 7-year TFR plan is a large-scale project in which 599 electric locomotives and 465 diesel electric locomotives will be procured for general freight business (GFB) use. The bidding of which is said at this time to close on February 26, 2013. According to the TRANSNET long-term plan, the transport volume of the entire rail freight is expected to increase from 212 million tons annually to 689 million tons annually and the GFB portion will increase from 73 million tons annually to 437 million tons annually in the 30 years between 2011 and 2041. Even after the 7-year plan is complete, a further increase in the transport volume is expected. It is believed that a large-scale increase in facilities for locomotives and freight trains will become necessary. There is ample room for Japanese companies to enter the market.

However, it is conceivable that the required level of local production will be raised in the future, making the entry conditions more stringent. As described in 4.3.1, some of the South African rolling stock companies engaging in repairs and refurbishment are now considering expanding into the manufacture of rolling stock in the future. From the standpoint of promoting the BEE Act as well, collaboration with these companies, in addition to the existing UCW and TRE, will continue to be necessary for entry into rolling stock manufacturing in South Africa. In reality, it is hard to imagine any foreign company, including the Japanese companies, can make entry on its own. Because these companies have no or little experience in the manufacturing of rolling stock, collaboration with them, including the transfer of technology, will be a prerequisite.

In terms of the supply of component parts, extremely high requirements will continue into the future. As can be seen in the procurement conditions of locomotives for GFB in 2012, the local production rate of electrical equipment will eventually be raised to 80%. Since many electrical parts are imported, it will be difficult to increase the rate of local contents drastically. In reality, it may be possible to seek exemption or have some form of collaboration with European companies that have already made entry at this time. In terms of mechanical parts, companies planning to make entry will have to provide support to local companies to help them expand production and enhance technological capabilities. Since this can be a burden on rolling stock manufacturers, one way is to make use of foreign loans and investment to educate and train local companies. If necessary, experts who support the policy proposal for training local companies and improving their technological capabilities shall be dispatched.

Based on needs, the Study Team should consider dispatching experts who are familiar with production and maintenance sites for a short term to support the actual technical transfer and training.

Figure 7-10 is a conceptual diagram of the above.



Source: Compiled by Study Team

Figure 7-10 Concept of Rolling Stock Localization

7.3.2 Signaling and Telecommunications

Based on the current state of localization and issues faced by the signaling industry in South Africa mentioned in Chapter 4 and taking into account the terms and conditions listed below: the Study Team selected the equipment and devices that are potential candidates for localization. They are listed in Table 7-4.

• The targets are limited to system equipment, field equipment, and software development of related equipment that require advanced technology; have plans for introduction; and have not been produced locally in the past.

• The targets are expected to have steady and continuous demand, have no restriction in terms of cost, and are in an environment that can promote quality improvement in the medium-to long-term development plans of railway companies for the future.

• The targets are in technical fields in which Japanese companies are fully competitive against their European counterparts.

Table 7-4 List of Equipment Targeted for Localization

	Target equipment	Approach to localization
System	Equipment for electronic interlocking	● Local production of peripheral parts and local assembly
		○ Import of control software and localization of interlocking control data
	Equipment for traffic control system	● Import of key component parts and local assembly
		○ Import of traffic control software and localization of data on display monitors
	Equipment for CTC	● Import of key component parts and local assembly
		○ Import of remote control software and localization of control data

	Ground equipment of ATP	● Local production of peripheral parts and local assembly
Field equipment	Axle detector	● Local production of peripheral parts and local assembly
	Warning equipment for level crossing	● Local production
	LED signal	● Local production
	Equipment for the monitoring of facility condition	● Local production of peripheral parts and local assembly
		○ Import of monitoring software and localization of data on display monitors

● : Hardware, ○ : Software
Source: Compiled by Study Team

As a first step for the Japanese companies to produce electronic interlocking equipment in South Africa, it is conceivable to import key electronic interlocking device with hardware and software, produce some non-core components locally, and then assemble the entire electronic interlocking system. In terms of software, local generation of control data will improve the efficiency of function inspection.

In tandem with transition to higher quality, the next step for Japanese companies is to increase some of the local production items. They will aim to increase local production rate gradually according to the conditions of the subcontractors. Traffic control equipment, CTC equipment, and other system equipment that require advanced technology will also follow similar process toward local production.

Next, field equipment that can be produced entirely locally includes level crossing warning system and long-life LED. The prerequisite for the latter will be an anticipated huge demand not only for railway signals but also for road traffic signals.

Regarding the local production of axle detector, which is expected to have large demand, the situation will change depending on whether European companies will switch at this time from a policy of complete import to producing some non-core parts locally and assembling axle detectors in South Africa. Although European companies already have experience introducing and taking measures in South Africa to prevent lightning damage, Japanese companies can compete well with their long years of expertise in lightning protection. In terms of cost, the possibility of local entry is significant.

Because the railway operator PRASA has adopted a policy that emphasizes maintenance in the bidding conditions, some local companies have expressed interest in the local production of equipment for monitoring the conditions of facilities. When Japanese companies make entry, it is desirable that they do not confine themselves simply to the local production of hardware but also work on localizing the development of software that will be useful and add value to maintenance management. Specifically, software for utilizing fault data, inspection data, and repair data obtained from the maintenance floors in South Africa shall be developed. Supports for disaster recovery and aftercare of repairs are also necessary.

To achieve localization, Japanese companies shall actively engage the wide range of local companies in the consulting, construction, maintenance, and manufacturing sectors as potentials candidates for collaboration. Actom, Mehleketo, and their subcontractors, which have proven record, are strong candidates. In fact, their cooperation with European companies varies in degree.

Depending on the candidate with whom to collaborate in local production, new market entrants from Japan will need to consider the method of partnership with these companies and newly

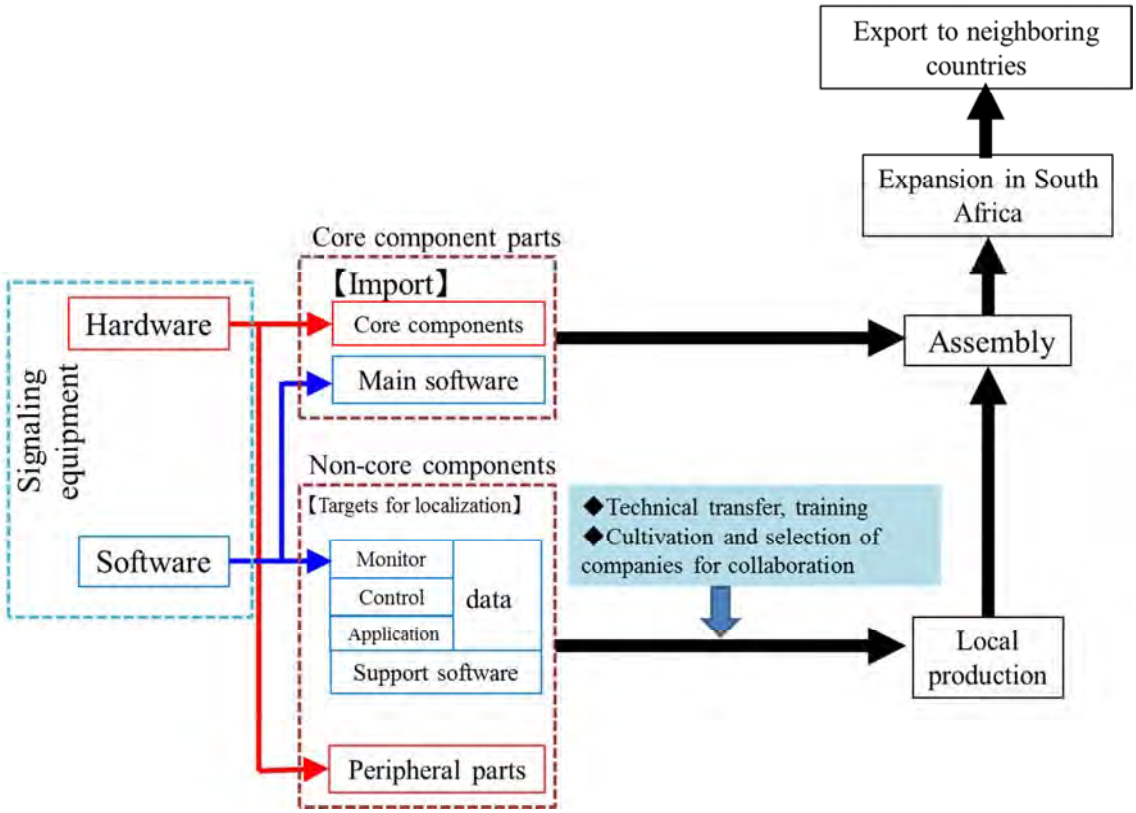
identified companies.

In promoting the entry of Japanese companies into the signal field, the Study Team shall consult the experience and wisdom accumulated over many years by Japanese companies that have made inroads in other fields.

Some European companies have continued and maintained production in South Africa for over 40 years, meeting the demands of customers. How they managed to comply and thrive in South Africa can serve as good reference.

However, rather than just following the footsteps of European companies, it is necessary to add values that are unique to Japan, such as maintenance technology.

Figure 7-11 is an approach of localization for the signal field.



Source: Compiled by Study Team

Figure 7-11 Approach of Localization of the Signal Field

7.3.3 Track

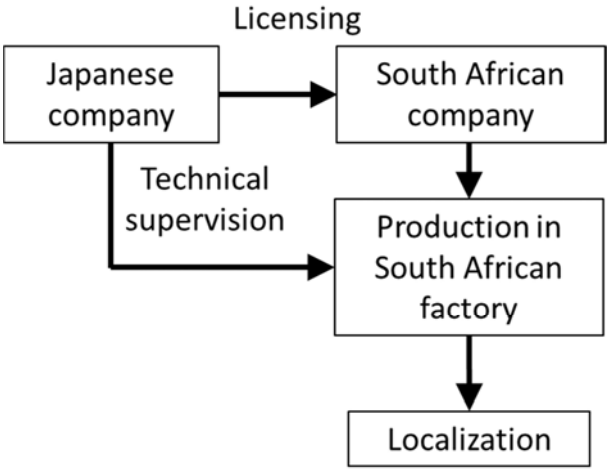
As for the market size of track, TFR replaced 471 km (FY 2009), 555 km (FY 2010), and 731 km (FY 2011) of rail in the past three years and maintained 528 km (FY 2010) and 690 km (FY 2011) of tracks in the last two years. Since both rail replacement and track maintenance are on the rise, track maintenance-related works are expected to increase in the future. The market size of concrete sleepers is also said to be 700,000 to 1 million annually. Given these operations and market sizes, there is possibility for Japanese companies to make entry.

(1) Track Materials

Ballast, concrete sleeper, and fastening device are already being produced locally in South Africa. As demand rises with implementation of the investment plans, the market size will expand, increasing the opportunity for Japanese companies to make entry. For example, the

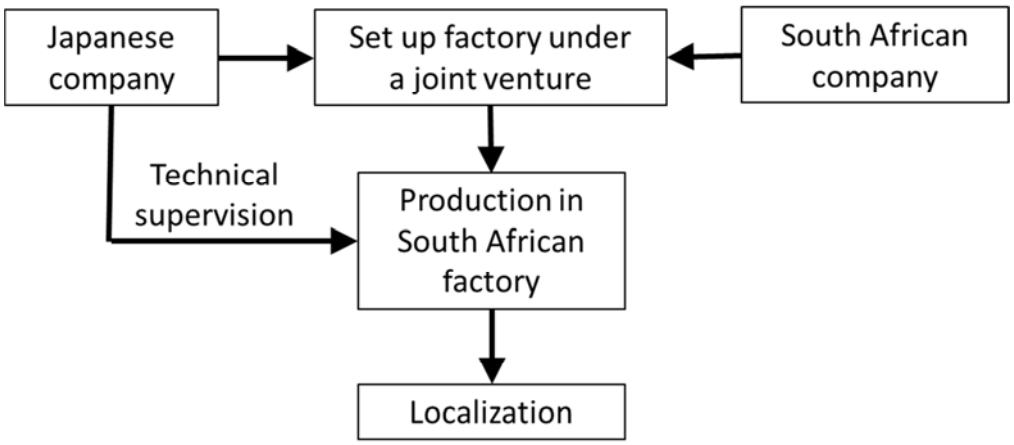
company Rail2Rail has introduced German technology for manufacturing prestressed concrete sleepers. Since it has only begun production in South Africa in 2010, the history is shallow. However, it has managed to grow into a major manufacturer of sleepers within a short time. Currently it accounts for 20–25% of the market share among sleeper manufacturers. In this respect, there is opportunity even for a late comer to enter the market if it can deliver the quality commensurate with the price. In particular, compound sleeper is a technology that South Africa does not have. Given the low quality of concrete sleepers, there is a possibility for introducing compound sleeper as an alternative to concrete sleeper.

On the other hand, South Africa is currently relying on imports for its rails. It is an area in need of local production. The challenge when introducing compound sleeper and rail to South Africa is its lack of technology. Figure 7-12 and Figure 7-13 provide approach for the local production of these track materials.



Source: Compiled by Study Team

Figure 7-12 Approach of Local Production of Track Materials (1)



Source: Compiled by Study Team

Figure 7-13 Approach of Local Production of Track Materials (2)

(2) Slab Track

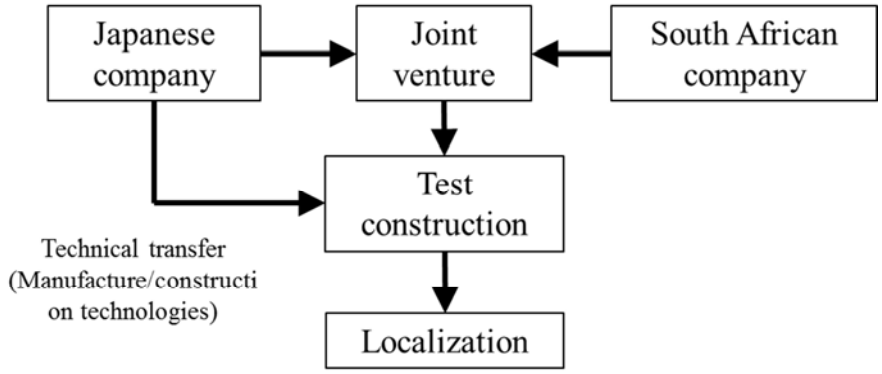
If the Japanese slab track is constructed properly as designed, high quality can be ensured. This requires closed construction supervision. Even if the Japanese slab track is introduced into South Africa, it will be difficult for local construction companies to carry out construction on their own at this time. It will necessitate Japanese companies specializing in the field to manufacture/construct the track slabs, manufacture/construct the filling layer (CA mortar),

provide supervision to ensure accuracy of the concrete roadbed, perform maintenance, adjust the long rails, and so on.

The challenge for introducing slab track is that the manufacture and construction of slab track requires advanced technology. However, South Africa does not have slab track technology.

In this case, it is effective to set up a joint venture between a Japanese company and a South African company, as it was done in China, so that the Japanese company can provide technical guidance.

Figure 7-14 provides an approach of local production.

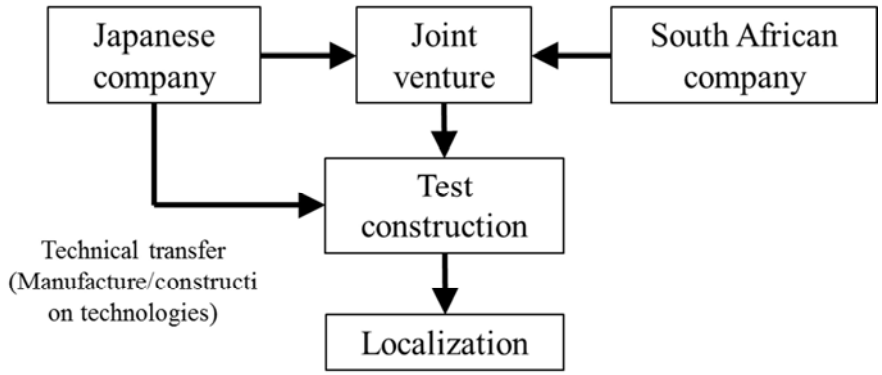


Source: Compiled by Study Team

Figure 7-14 Approach of Local Production of Slab Track

7.3.4 Automatic Fare Collection

For the automatic fare collection system, local production of the automatic ticket gate, which is a ground facility, is deemed possible. Figure 7-15 is an approach of localization.



Source: Compiled by Study Team

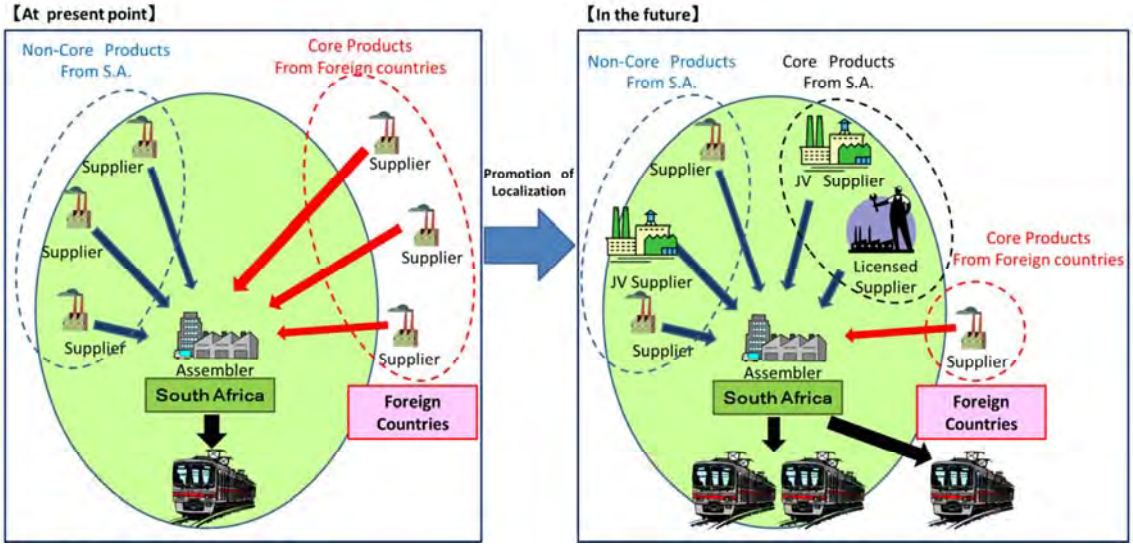
Figure 7-15 Approach of Local Production of Automatic Ticket Gate for Automatic Fare Collection

7.3.5 Combination Approach

7.3.1–7.3.4 offer examples of localization for rolling stock, signaling and telecommunications, track, and AFC. The need for technical transfer or technical guidance will be different depending on product item. However, localization of some of the core products, which rely mainly on imports, and non-core products, which are mainly produced in South Africa, will be promoted through the formation of joint ventures with foreign companies, including Japanese companies, or through licensing in the future.

Approaches of localization at present and in the future are shown in Figure 7-16. As efficiency

improves, South Africa will become more cost competitive. It is hoped that South Africa's industries will grow in the future to be able to export to neighboring countries as well as to Africa as a whole.



Source: Compiled by Study Team

Figure 7-16 Combination Approach to Localization

7.3.6 Railway-related Industries Pursuing Localization through Collaboration with Local Companies

(1) List potential companies in each sub-sector (technical capabilities, sales capabilities, degree of market entry)

1) Rolling stock (EMU, locomotive, freight car, passenger car)
Criteria for a local company to be considered as a business collaborate for the Japanese company:

- Local company (not foreign owned)
- Has not built up any network with foreign companies (collaboration with foreign companies as a supplier, etc.)
- Has relatively high BEE level (4 or above)

Table 7-5 shows the rolling stock-related companies in light of the above requirements.

Deriving from the abovementioned three criteria, the Study Team identified nine companies as potential candidates for collaboration. They are shown in Table 7-6.

Table 7-5　Overview of Rolling Stock-related Companies

No.	Name of company	Main product	Foreign company	Local company	Connection with foreign company							BEE Score
					GE（USA）	Siemens（Germany）	Alstom（France）	Bombardier（Canada）	Staddler（UK）	Hitachi	Toshiba	
1	UCW (Union Carriage & Wagon Company)	Rolling stock	○（UK）								○	
2	Grindrod	Mining/ locomotive		○								3
3	RRL Grindrod	Manufacture of locomotive		○								Operation department: Level 1, Locomotive manufacturing department: Level 3
4	Columbus Stainless	Stainless steel plate	○（Spain）									6
5	Macsteel VRN (Stainless Division)	Stainless materials		○			○	○				4
6	DCD Dorby1	Bogie		○		○				○	○	4
7	ABB	Main motor		○								-
8	Mersen South Africa	Carbon brush	○（France）									-
9	Timken South Africa (Pty) Ltd	Bearing	○（USA）								○	5
10	Rotacon Engineering	Gear box		○							○	1
11	Donkin Fans	Blower		○	○							4
12	Knorr-Bremse	Brake	○（Germany）									3
13	Rollmech (Pty) Ltd.	Main control equipment		○								-
14	LH Marthinusen	Coil, rectifier		○								3
15	OTD (Overhead Track Developments)	Pantograph		○		○						4
16	Siyahamba Engineering (Pty) Ltd	Car door/window		○	○							4
17	Booyco Engineering	Air-conditioning		○	○	○	○	○				5
18	SME	Air-conditioning		○				○				-
19	Inteletrack	Train separation detection device		○								-
20	Ansys Limited	Train position tracking system	○（USA）	○	○							5
21	Waymark Infotech	Electronic manual system		○								4
22	Naledi Rail Engineering	Rolling stock refurbishment		○								4
23	Surtees Investments (Pty) Ltd.	General supplier of component parts		○								8

Source: Compiled by Study Team

Table 7-6 Potential Candidates for Collaboration with Japanese Companies (rolling stock)

Name of company	Main products
Grindrod	Mining, locomotive
RRL Grindrod	Manufacture of locomotives
Rotacon Engineering	Gear case
Knorr-Bremse	Brake
Rollmech (Pty) Ltd.	Main control equipment
LH Marthinusen	Coil, rectifier
Inteletrack	Train separation detection device
Waymark Infotech	Electronic manual system
Naledi Rail Engineering	Rolling stock refurbishment

Source: Compiled by Study Team

Among the nine companies shown in Table 7-6 that the Study Team has interviewed, Rotacon Engineering showed interest in collaboration with Japanese companies. The Study Team confirmed that Rollmech (Pty) Ltd. is already using Japanese products as some of its master controller parts.

2) Signaling and Telecommunications (CTC, ATP, electronic interlocking device, level-crossing security system, field equipment)
Similar to rolling stock, Table 7-7 shows the situation of signaling and telecommunications manufacturers.

Deriving from the abovementioned three criteria, the Study Team identified Mehleketo as the potential candidate for collaboration, as shown in Table 7-8.

Table 7-7 Overview of Signaling and Telecommunications-related Companies

No.	Name of company	Main product	Foreign company	Local company	Connection with foreign company							BEE Score
					GE (USA)	Siemens (Germany)	Alstom (France)	Bombardier (Canada)	Staddler (UK)	Hitachi	Toshiba	
1	Lebone Engineering	Signal		○								4
2	Siemens	Signal	○(Germany)			○						-
3	Actom	Electrical equipment	○(UK)									3
4	Mehleketo	Construction of signals/railways		○		○		○				3

Source: Compiled by Study Team

Table 7-8 Potential Candidate for Collaboration with Japanese Companies (signaling and telecommunications)

Name of company	Main products
Mehleketo	Signal

Source: Compiled by Study Team

3) Track (rail, sleeper, turnout, fastening device)
Similar to rolling stock, signaling and telecommunications, Table 7-9 shows the situation of track-related companies.

Deriving from the abovementioned three criteria, we identified Tubular Track and Rail2Rail as the potential candidates for collaboration. SIMS has shown great interest in Japanese technologies. The three companies are shown in Table 7-10.

Table 7-9　Overview of Track-related Companies

No.	Name of company	Main product	Foreign company	Local company	Connection with foreign company							BEE Score
					GE（USA）	Siemens（Germany）	Alstom（France）	Bombardier（Canada）	Staddler（UK）	Hitachi	Toshiba	
1	Tubular Track	Track		○								2
2	Plasserail South Africa	Track maintenance	○（Australia）									3
3	Rail2Rail	Concrete sleeper		○								2
4	Pandrol	Rail fastening device	○（UK）									4
5	SIMS（Stimera Infrastructure Management Services）	Track/ Electric power/ Training						○				3

Source: Compiled by Study Team

Table 7-10　Potential Candidates for Collaboration with Japanese Companies (track)

Name of company	Main products
Tubular Track	Track
Rail2Rail	Concrete sleeper
SIMS（Stimera Infrastructure Management Services）	Track/Electric power/Training

Source: Compiled by Study Team

7.4　Roadmap

7.4.1　Direction of JICA Assistance Activities

(1) Utilizing the Various Experiences, Expertise, Forms of Assistance, and Financing Tools of JICA

JICA is the only institution in Japan that can offer across-the-board assistance, from yen loan, grant aid, to technical assistance. Through its past assistance activities, JICA has established an extensive network with the central/local governments, public/private enterprises, and related organizations in South Africa and Japan.

Offering assistance through JICA has the following advantages:

• JICA has tools that can provide consistent upstream to downstream support, ranging from project formation, formulation of master plan, implementation of feasibility study, design/construction/ maintenance and management, and operation.

• JICA has wide-ranging experiences. In the hardware areas, it has experience in civil engineering structures, track, rolling stock, railway systems, station buildings, and rolling stock inspection and repair facilities. In the software areas, it can provide technical guidance in design, construction, operation, maintenance and management; support in human resources development for railway traffic control, systems, organization reinforcement; and assistance in the formulation of technical standards.

• JICA also has many tools for human resources development, including technical assistance, dispatch of experts, Japan training, etc.

By mobilizing the diverse tools and resources that JICA has, JICA can provide assistance that addresses accurately the needs of South Africa using a comprehensive approach, from railway-related projects to the development of surrounding environment in the course of promoting the modernization of railway sector in South Africa. Cooperation between the public and private sectors can expedite development. Table 7-11 shows the assistance tools of JICA.

Table 7-11 Assistance Tools of JICA

Tool	Description	Examples of application
- Technical cooperation in conducting studies for development plans - Preparatory survey	• Support the formulation of master plans for the modernization of railway in South Africa, the related urban railways and intercity railways, urban transport systems, and development plans for areas along the railway lines • Conduct feasibility study for a specific plan for yen loan purpose	• National transport master plan • City transport master plan • Feasibility study
Preparatory survey for PPP infrastructure projects	• Conduct feasibility studies for public projects using yen loan and to promote private projects participated by Japanese companies that use PPP	• Provide information and networking assistance to private businesses • Provide assistance in the formulation of business plans
-Technical cooperation -Technical assistance	• Offer training in Japan to DOT, TRANSNET, and PRASA personnel responsible for actual operations in order to transfer technology • Dispatch experts to help form projects, strengthen organizations, set up legal framework, and provide education and training to staff • Provide equipment • Support the formulation of policy/ contract systems for PPP projects; enhance the capabilities of operation personnel at DOT, TRANSNET, and PRASA; and monitor operations • Support RSR in the formulation of technical standards	• Invite key personnel, conduct site tours • Training by country/topic, training of young people • Coordinate training with concerned organizations and businesses • OJT • Dispatch experts for short-term and long-term stays
Yen loan	• Provide project funding with favorable conditions such as long repayment period and low interest	• Construction and upgrade of civil engineering structures, track, signaling systems ,etc.
Grant aid	• Provide funds for the construction and upgrade of infrastructure and facilities, and rolling stock without the obligation for repayment	• Construction and upgrade of civil engineering structures and tracks • Construction and upgrade of rolling stock inspection and repair facilities, station buildings, and other facilities
Private Sector Investment Finance (PSIF)	• Investment in and financing for private businesses that are expected to have high risk, low returns • Investment and financing for projects that are expected to have development effects and project achievement	• Investment and financing for special purpose vehicles (railway companies)

Source: Compiled by Study Team

(2) Direction of Activities by Theme

From among the JICA tools mentioned above, the Study Team found the following assistance measures effective based on the results of local survey and interviews with railway-related personnel in promoting the modernization of railway sector in South Africa.

1) Technical Assistance : Preparatory Survey

- We propose conducting a comprehensive city development study for Cape Town or Durban City. It will include automatic ticket gates, smart card tickets, business development inside train stations, and connection with other transport modes at stations. These are typical features of urban railways in Japan. Taking the opportunity of the large-scale procurement of EMUs by PRASA to replace its aging trains, the Study Team can propose a railway system to enable functional urban development with focus on urban railways. The Study Team can promote understanding of the Japanese railway and increase the chance of introducing Japan's urban railway system to South Africa. Cape Town, in particular, has strong interest in urban transportation planning, including urban railway. Since it has a mindset for development, it is a city suitable for conducting a comprehensive city development study.
- South Africa is implementing the transport policy to link city centers and major international airports by railway. In Johannesburg, Gautrain, which was built as a PPP project, has already launched service in 2010. As part of this effort, the rail rink to connect the King Shaka International Airport and Durban's city center is being reviewed by KwaZulu-Natal province and Durban City. This line can also be used as part of the high-speed railway between Johannesburg and Durban. If it is extended to Pietermaritzburg, the capital of KwaZulu-Natal province, it can also be utilized as an intercity commuter line.
- TRANSNET gives priority to the transport of important routes due to its policy of "selection and concentration." It plans to make effective use of the branch lines (7,300 km) by entering into concession contracts with private railway companies. Its objectives are 1) to promote regional development, 2) to promote modal shift from road to rail, 3) to reduce transportation cost, 4) to encourage private sector to take part in railway business, and 5) to enhance the safety of road and rail transport. In particular, Free State province has conducted an independent study to review reusing the branch lines as intercity passenger railway lines.

2) Financial Support : Private Sector Investment Finance (PSIF)

As already pointed out in this report, railway-related projects in South Africa have certain risk, including the risk of project delay. On the other hand, companies from other countries are actively making efforts to participate in railway-related projects in South Africa. Competition, including cost, is becoming more intense. Since South Africa can be a base for the southern African region, it is a strategically important country not only to railway-related businesses but also to Japanese companies. In view of this point of view, and to encourage Japanese companies to make entry into South Africa proactively, the Japanese government shall use overseas investment scheme to provide financial support to Japanese companies that are planning to make entry into South Africa. More specifically, it is assumed that PSIF scheme will be utilized in the following operations:

- Project in which a Japanese company plans to build a factory in South Africa to manufacture rolling stock
- Railway-related PPP project in South Africa (in the case when a Japanese company acts as a special purpose vehicle)

3) Dispatch of Experts

a) Experts for Long-term Stay

As is evident from the results of this Survey, human resources development and training is an important issue in the modernization of railway sector in South Africa. In order to support such an important policy issue, it is effective to dispatch experts with experience in training railway personnel to the South Africa Department of Transport (DOT) on a long-term basis. At that time, it is desirable to dispatch groups of experts specializing in different areas, including rolling stock, signaling and telecommunications, track, and automatic fare collection, which are Japanese railway technologies that are applicable to South Africa. The following are contents of main technical guidance:

- Support establishment of the Faculty of Railway Engineering at Vaal University of Technology in Gauteng province
- Strengthen the functions of the School of Engineering under TRANSNET
- Cooperate with the Training Academy of PRASA
- Create program for enhancing railway technical capabilities
- Create program for transferring railway technologies
- Support the formulation of railway technical standards by RSR

b) Experts for Short-term Stay : Provide technical guidance to each railway sub-sector

- Rolling Stock

For the rolling stock sector, in order to improve maintenance technology, it is desirable to send experts to the railway operators TRE and PRASA on a short-term basis. In particular, disseminating the concept of preventive maintenance to prevent damage and the concept of preventive maintenance by analyzing failure data to prevent damage is an urgent task in order to enhance the safety and punctuality of rail transport.

- Signaling and Telecommunications

For the signaling and telecommunications sector, it is desirable to send experts to TRE and PRASA on a short-term basis to provide technical guidance (lecture, OJT) for the maintenance of signaling and telecommunication facilities.

- Track

For the track sector, since improving track maintenance technology is a challenge for both PRASA and TRE, it is desirable to send experts for a short term to provide technical guidance on the maintenance of track facilities. In addition, since the technical level of rail welding technology is low, the experts will also give technical guidance on rail welding.

4) Human Resources Development

a) Utilize Various Training Schemes

Including the training schemes offered by JICA, the Study Team would collaborate with the following organizations and companies and utilize their training schemes in Japan to introduce Japanese railway technologies and transfer the technologies for operation, maintenance, and management of railway. The training will be offered to working-level personnel at DOT, TRANSNET, and PRASA.

- Japan External Trade Organization (JETRO): Various seminars, invitation
- Japan Transport Cooperation Association (JTCA): Invite key personnel, provide training and study tours for working-level personnel, promote exchanges, etc.
- International Development Center of Japan (IDCJ): human resources development projects, international exchange projects
- Railway operators: Inspection, receiving trainees
- Train operators: inspection, receiving trainees

b) Promote Exchanges of Personnel

Invite key personnel of railway-related organizations in this Survey to Japan to introduce Japanese railway system and technologies, including the following contents:

- Introduce the Japanese urban railway system and high-speed railway system (Shinkansen)
- Introduce the current state of Japanese railway technologies and technologies applicable to South Africa
- Promote understanding of the legal framework, business schemes, financing, and management of Japanese railways
- Ride Japanese railways, inspect operation control centers and railway facilities, inspect construction sites

7.4.2 Review Roadmap for the Modernization of the Railway Sector

In creating the roadmap for the modernization of the railway sector in South Africa, the Study Team reviewed with the viewpoints stated below. The results are shown in Table 7-12.

(1) South Africa's Investment Plans

Currently, PRASA and TRANSNET are planning to upgrade the signaling systems and increase the transport capacity of main lines, including procurement of rolling stock. They are shown in planning periods by major sub-sector. In the final draft of NATMAP, the Johannesburg–Durban high-speed railway is also proposed. This project is also a target of the investment plans.

(2) Measures to Realize the Project

As is evident from the results of this survey, in order to implement the investment plans being planned in South Africa and make them effective, it is necessary to cultivate human resources, enhance technical capabilities, and nurture supporting industries for the railway sector. In addition, since there is plan to establish South Africa as a base for railway industry in southern Africa in the future, it is necessary to collaborate with Japanese companies in the railway sector and to pursue local production.

(3) Entry of Japanese Companies

On the other hand, for Japanese railway-related companies to enter the South African railway market, they must collaborate with local companies, provide technical guidance, and make efforts to produce locally.

(4) Assistance Measures by Japanese Government

In order to facilitate modernization of the railway sector in South Africa and nurture railway industry through collaboration with Japanese companies, the Japanese government (METI and JETRO) can support collaboration with local companies and provide business-matching service.

(5) Priority of JICA Assistance Measures

Dispatching experts, conducting preliminary studies for cooperation, and overseas investment and financing are some of the JICA assistance measures that can be used to support the modernization of the railway sector in South Africa. Based on the current state of the railway sector in South Africa elucidated by this Survey and the needs of DOT and provincial governments, the railway operators TRANSNET and PRASA, and railway-related companies in South Africa, the Study Team listed the assistance measures of JICA in Table 7-12. To move forward with the modernization of the railway sector in South Africa in the future, the Study Team created a roadmap. The Study Team has prioritized the listed assistance measures (into A, B, C with A as the highest priority), taking into consideration the effects and feasibility of each assistance measure.

Table 7-12　Roadmap for the Modernization of Railway Sector

				Fiscal Year											
				2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
South Africa	Project	TRANSNET	General	7-year investment plan											
			Rolling stock	Procure rolling stock											
			Signal	Introduce double-track CTC, shorten headway between trains, upgrade and improve signaling and telecommunications facilities (～2025)											
			Electric power	Upgrade overhead contact lines, construct new substations, and electrify double tracks (～2036)											
			Civil engineering	Increase transport capacity of major lines (Iron Ore Line, Coal Line, and manganese line) and conduct studies of new lines (Swaziland Link, Waterberg)											
		PRASA	Rolling stock	Procure rolling stock (3600 units)【Phase 1】										Procure rolling stock (3600 units)【Phase2】	
			Signal	Modernize signaling system											
			Electric power	Upgrade overhead contact lines in tandem with the introduction of new rolling stock and upgrade of signaling system											
			Civil engineering		Modernize infrastructure										
			Others					Revitalize urban railway							
		High-speed railway			Conduct studies (local contract)										
	Measures to form projects				Train human resources/ Enhance technical capability										
						Nurture supporting industries									
						Collaborate with Japanese companies									
							Local production								
														Export railway to neighboring countries	
Japan	Participation of Japanese companies		Rolling stock			Collaborate with local rolling stock manufacturers and provide technical assistance									
			Signal			Provide technical transfer and train collaborating companies									
			Track			Provide technical guidance and technical transfer									
			AFC						Provide technical transfer						
	Governmental support	METI, JETRO			Support collaboration with local companies										
					Business matching										
	JICA assistance measures	Conduct study of railway sector		This Survey											
		Dispatch experts for long-term stay			Dispatch human resources experts to DOT (Team for each specialty)										
		Dispatch experts for short-term stay	Rolling stock			Rolling stock experts									
			Signal			Signaling experts									
			Track			Track maintenance experts									
		Preparatory Survey				Study for the development of urban centers									
								Feasibility study of airport link							
		Private Sector Investment Finance (PSIF)				Factory construction projects									
											PPP projects				
		Exchange of human resources			Study for the development of urban centers										
		Training in Japan			Transfer technology to working-level personnel and young engineers at DOT, TRANSNET, and PRASA										

Source: Compiled by Study Team

Legend: : A（1st priority） : B（2nd priority） : C（3rd priority）

7.4.3 Calculating the Volume of Investment and Job Creation Effects

The Study Team has provided a roadmap for the modernization of the railway sector in South Africa in 7.4.1 and 7.4.2. It is necessary to make steady effort to achieve this roadmap in the future.

In this section, the Study Team will estimate the effects of job creation in South Africa by putting this roadmap into practice to demonstrate the importance of its realization.

TRANSNET and PRASA have formulated long-term investment plans to work towards the modernization of the railway sector in South Africa and they are conducting profitability Analyses and analysis of the job creation effects. Although they have performed detailed demand forecast, their analyses are premised on high growth over the long term. There can be risk factors whether such high growth will materialize. In this section, The Study Team performs a sensibility analysis of profitability when economic growth, the premise of demand forecast, is revised downward. From its results, the Study Team estimates the scale of investment assuming that the economy is weak and then calculate the effects of job creation.

(1) Estimation of Investment Plans

1) Demand Forecast

Both TRANSNET and PRASA assume a GDP growth rate of over 4% in the future. Based on the outlook laid out in 5.1, there is the possibility of over forecasting. Therefore, using the outlook as reference, the Study Team estimated the demand based on a 3% GDP growth rate in the future.

In the demand forecast results published by PRASA, the number of passengers is estimated to be approximately 595 million a year. Assuming certain growth in population and an annual GDP growth rate of about 4.4%, the number of passengers is estimated to be 650 million a year in 2030. That is, the number of passengers increases at the rate of 0.466% per year (= $(6.50/5.95)^{1/19}$-1). Since the demand forecast of PRASA considers population growth and economic growth as the major factors leading to increase in demand, the Study Team used the assumption that the rate of contribution of economic growth is half and that the number of passengers increased from economic growth is at a rate of 0.233% per year. Here, if the rate of economic growth is 4.4% annually, the rate of increase in demand per 1% of annual economic growth rate is 0.053% (= 4.4% / 0.233%). Thus, if the rate of economic growth is 3% annually, the increase in demand due to economic growth is 0.159% (=3%*0.053%). Adding the 0.233% rate of increase in demand due to population growth, the increase in demand will be 0.392% if the economic growth rate is 3%. As a result, if the economic growth rate is 3% in 2030, the number of passengers a year is estimated to be approximately 641 million (=$5.95*(1+0.392\%)^{19}$). Table 7-13 shows the results of sensitivity analysis of the PRASA demand forecast.

Table 7-13 Results of Sensitivity Analysis of the PRASA Demand Forecast

	Basic case (Economic growth rate of over 4%)		Sensitivity analysis case (Economic growth rate of 3%)
Number of passengers annually	Approximately 650 million (2031)	→	Approximately 641 million (2030)

Source: Compiled by Study Team

In the demand forecast results published by TRANSNET, the rail freight handled in 2011 is approximately 212 million tons. Assuming certain growth in population and an annual GDP growth rate of about 4.4%, the rail freight is estimated to be 689 million tons a year in 2041.

That is, the rail freight increases at the rate of 4.007% (=(689/212)$^{1/30}$-1). Here, if the rate of economic growth is 4.4% annually, the rate of increase in demand per 1% of annual economic growth rate is 0.911% (=4.4%/4.007%). Thus, if the rate of economic growth is 3% annually, the increase in demand is 2.732% (=3%*0.911%). As a result, if the economic growth rate is 3% in 2041, the rail freight is estimated to be approximately 476 million tons a year (=212*(1+2.732%)^{30}). Table 7-14 shows the results of sensitivity analysis of the TRANSNET demand forecast.

Table 7-14 Results of Sensitivity Analysis of the TRANSNET Demand Forecast

	Basic case (Economic growth rate of over 4%)		Sensitivity analysis case (Economic growth rate of 3%)
Rail freight handled annually	Approximately 689 million tons (2041)	→	Approximately 476 million tons (2041)

Source: Compiled by Study Team

2) Estimation of Investment Plans

Based on the downward revised demand forecast results in 1) above, the Study Team estimated the scale of investment commensurate with the demand forecast. In the PRASA and TRANSNET investment plans, the long-term items, in particular, assume growth of demand because their objectives are to expand transport capacity. When the demand is revised downward, the scale of investment will also be revised downward.

More specifically, the PRASA investment plan considers procuring 7,224 units of rolling stock by 2030 (of which, 1,968 units are to meet increase in future demand). As mentioned above, since the overall demand will decline by 1.39% as of 2030 (=641 million people/650 million poeple-1), assuming that the investment in rolling stock will decline by 1.39%, if the economic growth rate is 3%, investment in the number of rolling stock until 2030 will be approximately 7,123 units. It is possible that the number of rolling stock to be procured will be reduced by approximately 100 units, as compared to the current investment plan. Table 7-15 shows the estimated results of the PRASA investment plan.

Table 7-15 Estimated Results of PRASA Investment Plan

	Basic case (Economic growth rate of over 4%)		Sensitivity analysis case (Economic growth rate of 3%)
Investment in rolling stock	7,224 units (by 2030)	→	Approximately 7,123 units (by 2030)

Source: Compiled by Study Team

Similarly, the Study Team reviewed the investment in rolling stock by 2041(664 billion ZAR by 2041) in the TRANSNET investment plan. As mentioned above, since the overall demand will decline by 30.93% as of 2041 (=476 million tons/689 million tons-1), assuming that the investment in rolling stock will decline by 30.93%, if the annual economic growth rate is 3%, investment in the number of rolling stock until 2041 will be approximately 522 billion ZAR. It is possible that the investment plan for rolling stock will be reduced by approximately 140 billion ZAR, compared to the current investment plan. Table 7-16 shows the estimated results of the TRANSNET investment plan.

Table 7-16 Estimated Results of TRANSNET Investment Plan

	Basic case (Economic growth rate of over 4%)		Sensitivity analysis case (Economic growth rate of 3%)
Investment in rolling stock	664 billion ZAR (as of 2041)	→	552 billion ZAR (as of 2041)

Source: Compiled by Study Team

In addition, if the various initiatives shown in 7.1 to 7.3 are not carried out steadily, even the downward revised demand shown here will not materialize. It is necessary to cooperate with other transportation entities in the cities, steadily improve the level of technology, and so on.

In addition, if the latest investment plans of PRASA and TRANSNET (7-year year plan in the case of TRANSNET) move forward steadily, the service level of transportation will improve. As a result, the Study Team can expect improvement in transport efficiency, operational efficiency, and convenience in everyday life along the railway lines. Their accumulated effects will be the underlying forces for economic growth in South Africa. The Study Team can even anticipate demand greater than the downward revised demand described above. In this way, success of the immediate investment plans will lead to increased demand in the long term. As it will lead to the continuation of long-term investment and increase in job creation effects, it is necessary to promote cooperation with other transportation entities in cities and improve the technical level in order to contribute to the success of the immediate investment plans.

(2) Estimation of Job Creation Effects

The Study Team estimated the effects of job creation at TRANSNET and PRASA. In this Survey, the Study Team examined to what degree job creation effects decline when the scale of investment is premised on the demand of the safe scenario in (1)

At PRASA, its current investment plan is expected to have the effect of creating 65,992 jobs by 2030. If the rate of economic growth becomes 3%, assuming that the effect of job creation will decline at the same rate of decrease (-1.39%) in the investment plan due to the decline in demand, the job creation effect will be about 65,072 people.

Table 7-17 shows the estimated results of the job creation effects at PRASA.

Table 7-17 Estimated Results of PRASA Job Creation Effects

	Basic case (Economic growth rate of over 4%)		Sensitivity analysis case (Economic growth rate of 3%)
Job creation effects	65,992 jobs (total as of 2030)	→	65,072 jobs (total as of 2030)

Source: Compiled by Study Team

It is the same for TRANSNET. Its current investment plan is expected to have the effect of creating 132, 974 jobs annually by 2041. If the rate of economic growth becomes 3%, assuming that the effect of job creation will decline at the same rate of decrease (-30.93%) in investment plan due to the decline in demand, the job creation effect will be about 115,072 people annually. Table 7-18 shows the estimated results of the job creation effects at TRANSNET.

Table 7-18 Estimated Results of TRANSNET Job Creation Effects

	Basic case (Economic growth rate of over 4%)		Sensitivity analysis case (Economic growth rate of 3%)
Job creation effect	132,974 jobs (annual average until 2042)	→	115,072 jobs (annual average until 2042)

Source: Compiled by Study Team

As shown above, if the roadmap is put into practice, the job creation effects will be huge even if the economic growth rate becomes about 3% in South Africa. In addition, job creation will induce transport demand, thus augmenting the use of PRASA and TRANSNET and stimulating economic activities. In this way, it is important to express the effect of steady job creation as positive feedback.

This job creation effect will be realized by achieving the goals of South Africa's current local production rate. It is necessary to ensure this effect and take initiatives to steadily improve the technical level of the railway sector in South Africa.

Chapter 8

Overview of the Outcomes of South Africa – Japan Railway Conference

Chapter 8 Overview of the Outcomes of South Africa–Japan Railway Conference

8.1 Overview of Railway Conference

From January 21 (Monday) to January 24 (Thursday), 2013, the JETRO Johannesburg Office, Japanese Embassy in the Republic of South Africa, and JICA Office in the Republic of South Africa jointly held the South Africa–Japan Railway Conference in Johannesburg, Durban, and Cape Town.

In addition to the full support of South Africa's Department of Transport (DOT), the Study Team also had cooperation of the KwaZulu-Natal Provincial Government and eThekwini Municipality for the Durban Conference and cooperation of the Department of Transport and Public Works (Western Cape Government) for the Cape Town Conference.

The conferences were held with the objectives to take part in the growing debate on the modernization of the railway sector and high-speed railway in South Africa and to raise awareness about Japan's assistance schemes for facilitating development of the railway industry; Japan's experiences in the development of railway systems and regional, social, and technological development; the technological superiority of the Japanese railway system; and the experiences of Japanese companies in order to foster understanding that Japan is the best partner for South Africa in the modernization of its railway sector.

In addition to reporting the outcomes of the "Data Collection Survey on Railway Sector in the Republic of South Africa" at the Conference, the Study Team also gave presentations on the Johannesburg–Durban high-speed railway[1] and automatic fare collection (AFC) (*Suica* card)—

topics that are of great interest to South Africa. The Study Team also prepared a pamphlet summarizing the outcomes of the Survey and distributed it to Conference participants to disseminate the Survey results. A questionnaire was used to find out opinions on the proposed roadmap for the modernization of the railway sector.

Table -8.1 Schedule of the South Africa–Japan Railway Conference

Schedule	Location	Venue	Participants (Note)
January 21, 2013 (Monday)	Johannesburg	Midrand, Gallagher Convention Centre	116
January 22, 2013 (Tuesday)	Durban	Hilton Durban	94
January 24, 2013 (Thursday)	Cape Town	Southern Sun Cape Sun	67

(Note) The numbers of participants include speakers and administrative personnel
Source: Compiled by Study Team

8.2 Contents of Railway Conference

Since the interest in/need for railway development and the direction of railway development in the future differ depending on the city, the Study Team selected themes specific to each city in an effort to obtain an accurate understanding of the needs of South Africa. In general, the presentations given by the Survey Team were well received.

[1] Reported the findings of the "Study on High Speed Railway Project between Johannesburg and Durban in the Republic of South Africa"
(February, 2012, commissioned by the Ministry of Economy, Trade and Industry (METI) of Japan and conducted by Japan Railway Technical Service and Mitsubishi Research Institute)

8.2.1 Johannesburg

(1) Main Themes

1) Japan's latest railway systems and socio-economic development through railway construction
2) Localization and industrialization of South African railway industry

(2) Main Participants

Portfolio Committee, DOT, DTI, TRANSNET, PRASA, and provincial governments, etc.

(3) Program

Session I	
09:30-09:35	Welcome Address Mr. Yutaka Yoshizawa, Ambassador of Japan
09:35-09:40	Opening Address Dr. Lanfranc Situma, Deputy Director General: NATMAP 2050, Department of Transport
09:40-09:45	Introduction: Japanese Government Policy to Promote Infrastructure-related Businesses Mr. Atsuhiko Hatano, Deputy Director-General, Trade and Economic Cooperation Bureau, Ministry of Economy, Trade and Industry
09:45-10:15	Key Note 1: State of Art – Japan's Railway System and Our Future Ms. Nozabelo Ruth Bhengu, Chairperson, Portfolio Committee on Transport
10:15-11:00	Key Note 2: Railway System in Japan – Its Advantages and Contribution to Social Development Mr. Shota Utsubo, Special Assistant to the Director, Office of Project Development, Railway Bureau, Ministry of Land, Infrastructure, Transport and Tourism
11:00-11:15	Report: Summary of Pre-Feasibility Studies on the Possible High Speed Railway between Johannesburg and Durban Mr. Yoshimasa Sakon, Senior Manager, Technology Headquarters, Japan International Consultants for Transportation
11:15-11:30	Discussion / Q & A Session
11:30-11:50	Coffee Break
Session II	
11:50-12:00	Presentation: JICA's Support Schemes for Railway Sector Development Mr. Satoru Matsuyama, Deputy Director, Division 3, Africa Department, JICA HQ
12:00-12:45	Report from JICA Survey: Modernization of SA Railway System and Solution for its Industrialization Mr. Yoshihiro Akiyama, Director, Technology Headquarters, Japan International Consultants for Transportation
12:45-13:00	Report: Observation on Japan's Railway System Prof. M M Ndege, Executive Dean, Faculty of Engineering and Technology, Vaal University of Technology
13:00-13:10	Presentation: Strategy for the Further Localization and Transfer of Advanced Technologies Mr. Shinsuke Tachibana, Marketing Executive, Railway Systems Div., Toshiba Corporation
13:10-13:30	Discussion / Q & A Session

(Note) The highlighted presentations were delivered by Study Team members.

8.2.2 Durban

(1) Main Themes

1) Japan's experience in high-speed railway (shinkansen) and socio-economic development through shinkansen construction
2) Development of high-speed railway in the Johannesburg–Durban section

(2) Main Participants

Portfolio Committee, DOT, DTI, TRANSNET, and provincial governments, etc.

(3) Program

Session I	
09:30-09:35	Welcome Address Mr. Yasuhide Yamada, Director-General, Department of Manufacturing and Environment Industry, Japan External Trade Organization (JETRO)
09:35-09:40	Opening Address Mr. Obed Mlaba, Chairman, Board of Directors, Trade & Investment KwaZulu-Natal (TIKZN)
09:40-10:10	Key Note 1: State of Art – Japan's Railway System and Our Future Ms. Nozabelo Ruth Bhengu, Chairperson, Portfolio Committee on Transport
10:10-10:55	Key Note 2: History of Japan's High Speed Railway and its Contribution to Social Development Mr. Shota Utsubo, Special Assistant to the Director, Office of Project Development, Railway Bureau, Ministry of Land, Infrastructure, Transport and Tourism
10:55-11:10	Discussion / Q & A Session
11:10-11:20	Coffee Break
Session II	
11:20-11:50	Report: Summary of Pre-Feasibility Studies on the Possible High Speed Railway between Johannesburg and Durban Mr. Yoshimasa Sakon, Senior Manager, Technology Headquarters, Japan International Consultants for Transportation
11:50-12:00	Presentation: JICA's Support Schemes for Railway Sector Development Mr. Satoru Matsuyama, Deputy Director, Division 3, Africa Department, JICA HQ
12:00-12:30	Report from JICA Survey: Modernization of SA Railway System and Solution for its Industrialization Mr. Yoshihiro Akiyama, Director, Technology Headquarters, Japan International Consultants for Transportation
12:30-12:40	Presentation: Toshiba's Railway Business and Supplier's Development in South Africa Mr. Shinsuke Tachibana, Marketing Executive, Railway Systems Div., Toshiba Corporation
12:40-12:55	Discussion / Q & A Session
12:55-13:00	Closing Remarks Mr. Eric Apelgren, Head: International and Governance Relations, Ethekwini Municipality

(Note) The highlighted presentations were delivered by Study Team members.

8.2.3 Cape Town

(1) Main Themes

1) Japan's urban railway systems and socio-economic development through the construction of urban railways
2) Utilization of Japan's latest technologies to improve comfort and convenience of the urban railway in Western Cape province.

(2) Main Participants

Portfolio Committee, DOT, DTI, PRASA, and provincial governments, etc.

(3) Program

Session I	
09:30-09:35	Welcome Address Mr. Yasuhide Yamada, Director-General, Department of Manufacturing and Environment Industry, Japan External Trade Organization (JETRO)
09:35-09:40	Opening Address Mr. Robin Carlisle, Provincial Minister for Transport and Public Works, Western Cape Government
09:40-10:10	Key Note 1: State of Art – Japan's Railway System and Our Future Ms. Nozabelo Ruth Bhengu, Chairperson, Portfolio Committee on Transport
10:10-10:55	Key Note 2: Urban Railway System in Japan – Its Advantages and Contribution to Social Development Mr. Shota Utsubo, Special Assistant to the Director, Office of Project Development, Railway Bureau, Ministry of Land, Infrastructure, Transport and Tourism
10:55-11:10	Discussion / Q & A Session
11:10-11:20	Coffee Break
Session II	
11:20-11:50	Report: *Suica* – Advanced Ticketing System in Japan and Its Impact on the Creation of New Services Mr. Masahiro Watanabe, Deputy General Manager, Technology Headquarters, Japan International Consultants for Transportation
11:50-12:00	Presentation: JICA's Support Schemes for Railway Sector Development Mr. Satoru Matsuyama, Deputy Director, Division 3, Africa Department, JICA HQ
12:00-12:30	Report from JICA Survey: Modernization of SA Railway System and Solution for its Industrialization Mr. Yoshihiro Akiyama, Director, Technology Headquarters, Japan International Consultants for Transportation
12:30-12:40	Presentation: Toshiba's Railway Business and Supplier's Development in South Africa Mr. Yasuto Suzuki, Deputy General Manager, Toshiba Corporation Sandton Office
12:40-12:55	Discussion / Q & A Session
12:55-13:00	Closing Remarks Councilor Brett Herron, Mayoral Committee Member for Transport, Roads and Storm Water, City of Cape Town

(Note) The highlighted presentations were delivered by Study Team members.

8.3 Summary of Main Opinions

The following summarizes the main opinions obtained from the conferences held in three cities:

8.3.1 Johannesburg

(1) South African Government Official A

The official commented that Japan is operating an efficient transportation network made up of road, rail, ship, and air transport. In contrast, the OR Tambo International Airport in Johannesburg is the only airport in South Africa that is connected to the railway.

To solve the lack of skills of the domestic labor force, the South African government established a higher education institution in 2009. Budget for capacity building was also added to the 2011 budget of the Department of Science and Technology. South Africa is now beginning to identify priority areas and skills that need to be developed. In implementation, it is vital to have the cooperation of the business sector and the parents of students receiving the education.

(2) South African Government Official B

The South African government wants to develop safer and more efficient means of transportation and to grow domestic industries via an ambitious plan for improving the railway network. In addition to putting in place railway facilities, South Africa also wants to bring up railway engineers. Such plan also gives rise to the possibility of connecting to the railway networks in various parts of South Africa.

For the implementation of such large-scale plan, I visited Japan[2] as a potential partnering candidate because it is at the forefront of the railway field. One of the objectives was to find out what made the Japanese railway successful.

I heard that the shinkansen did not have any casualties during the major earthquake on March 11, 2011. This fact symbolizes the strength of the Japanese railway sector. I would like to work with Japan to improve the railway sector of South Africa.

(3) South African Government Official C

The Johannesburg–Durban high-speed railway plan will take time. Japan took the lead in conducting a pre-feasibility study. The Study Team will report the study findings to the new Minister of Transport and prioritize the works that need to be done. Ultimately, our goal is to provide the maximum benefit to the people of South Africa.

Capacity development is one of the priorities of the Department of Transport. In 2011, fifteen members from the Department of Transport went to Japan for training. They will be in a position to play an active role as trainers from now on. Based on their input, the Study Team is revising our training program. Through such training, the Study Team is bringing up our own in-house staff. Currently, the Study Team is in the process of selecting partner educational institutions. Tshwane University of Technology (TUT), Vaal University of Technology (VUT), and University of Cape Town are the candidates. The Study Team is considering the establishment of railway engineering departments at these universities.

The education and training that the Study Team has in mind are intended not only for South Africa but also for the rest of the African continent. Our policy is to train people who are interested in technology. Although South Africa has a railway sector, The Study Team has not really brought up our railway industry. I think education and training are keys to the industrialization of the railway sector.

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[2] JETRO invited South Africa's key railway personnel to visit Japan during January 12–20, 2013. Five top officials visited Japan and inspected Japan's railway systems.

(4) South African Government Official D

I am concerned if modernization of the railway sector in South Africa is sustainable. After introduction of the Japanese railway technologies, the technologies shall be transferred properly under the guidance of the Portfolio Committee so that South Africa can perform maintenance on its own.

(5) Representative of Japanese Company in South Africa

The Study Team was delivering railway vehicles to TRANSNET until 1988 but the orders stopped for some time. In collaboration with Toshiba's local partner UCW, the Study Team obtained an order in 2006 to deliver locomotives for the Coal Line and the Iron Ore Line. It was the first locomotive order placed by TRANSNET after the abolition of Apartheid.

During the period when there were no orders, UCW lost its production expertise, thus causing significant delay in production. To overcome this problem, UCW changed its management and reorganized its production program, making it possible to deliver the 100 locomotives for the Coal Line and 44 locomotives for the Iron Ore Line.

Through such undertakings, the Study Team accumulated experiences in working with South African partners. The Study Team also contributed to the South African economy through job creation and technical transfer. The Study Team hopes to contribute to the economic and social development of South Africa in the future through participation in the plan to introduce electric locomotives to TRANSNET, recruitment of blacks, and so on.

8.3.2 Durban

(1) Municipality Official A

Although the railway industry of South Africa is still under development, I think it has the potential to develop to the fullest. The idea that Johannesburg and Durban can be connected in three hours through the construction of a high-speed railway is a dream come true for the South African people. I truly believe that this Survey will not end with a presentation but it will become a reality. The findings of Japan's high-speed railway study provide an opportunity to promote the high-speed railway vision to South Africa. It will be desirable to have Japan's participation in the modernization of South Africa's railway sector in the future.

(2) Municipality Official B

Thank you for showing us that the high-speed railway plan has the possibility of saving us from driving long hours from Durban to Johannesburg. Considering the contents of the presentations at the Conference, I think it is necessary to find ways for the bus and taxi industries to collaborate with the high-speed railway and to expand black economic empowerment. I wish to thank our Japanese partner again for working with us to make lives better.

8.3.3 Cape Town

(1) South African Government Official A

TRANSNET and PRASA recognize the importance of cooperating with the national governmental agencies. The Study Team communicated with each other during the formulation of NATMAP. I think it is necessary to strengthen the organizational structure of South Africa as a whole in the future. The Study Team has also discussed with the Japanese representatives about the total solution that the Study Team wants to pursue. In the future, the Study Team will work on solutions by utilizing Japan's experiences in the education and other fields in conjunction with improving our road network.

(2) Municipality Official A

Cape Town's public transportation is inefficient and inconvenient. It is viewed as an expensive system in some cases. Overcoming these weaknesses is necessary to promote the economic development of Cape Town. Although various efforts are being made to improve the public transportation network, improvement cannot be accomplished within a short time. Keeping in sight the greater picture, the Study Team needs to make continued effort to improve user experience in the city's public transportation by integrating various transportation modes. Railway is a critical infrastructure that supports South Africa; it is equally important to Cape Town.

The Study Team recognizes that universal access is an important initiative. For the automatic ticket gate, Cape Town has adopted an automatic fare collection system based on the EMD technology. Since *Suica* card uses the near-field communication (NFC) technology, the Study Team would like to use it for reference. The presentation gave examples of station development by the private sector in Japan. Cape Town is also in the midst of a discussion about the feasibility of such endeavor. The Study Team has a great deal to learn from the Japanese examples.

8.4 Major Questions and Answers

1	Q	When we were planning for the Gautrain (12 years ago), we asked Japan to participate but there were no suitable partners. I understand that the system at the time did not allow Japan to participate in any PPP projects. Now that 12 years have passed, has the system in Japan changed?
	A	I believe that Japan can now participate in PPP projects. I understand that Japan has great interest in the construction of a high-speed railway line between King Shaka International Airport and Durban, as shown in the roadmap presented in the survey study.
2	Q	Questions regarding the study on high-speed railway between Johannesburg and Durban: 1）In the presentation, the construction cost of the high-speed railway between Johannesburg and Durban was said to be 160 billion ZAR. How did you calculate the operating cost? 2）Has any financing mechanism been determined? Will private sector funds come from Japanese companies or the government? 3）You recommended Route B but I understand that the tracks on this route are very old. Isn't Route B not a good option? 4）What will be the role of the KZN Department of Economic Development in the planning of this high-speed railway line from now on? 5）The numbers of new jobs that will be created during the construction and after the start of service 6）Range of JICA PSIF
	A	1）The construction cost was calculated taking into consideration local cost. The rolling stock procurement cost was calculated on the assumption that the rolling stock will be purchased from Japan. The operating cost was calculated based on the experience of operating the shinkansen in Japan. 2）The assumption is that 70% of the funds will come from the government and 30% from the private sector. This is only a proposal. Further review will be conducted. 3）The Study Team proposed not to use the existing track but to build standard gauge (1435 mm) track for Route B. 4）Japan took the initiative to conduct a pre-feasibility study but it will be up to

		South Africa to realize this vision. It is desirable for the concerned parties in Johannesburg and Durban to deliberate with each other to make the vision a reality. Since this is a South African project, it is up to South Africa to decide on the financing scheme. 5）Route B is expected to create jobs for 350,000 people during construction and for 7600 people annually after the start of service. 6） Since the PSIF scheme restarted in 2012, it only adopted two cases. The range is on a case-by-case basis. The future amount is being discussed.
3	Q	Have any other countries conducted studies on South Africa's railway sector like the ones by Japan?
	A	There are other countries showing interest in the high-speed railway plan but I have not heard of any that has done a study like the ones by Japan.
4	Q	1）What is the relationship between passenger railway and freight railway in Japan? 2） What are the main causes of level-crossing accidents in Japan?
	A	1） We use a freight management system. Depending on the area, we have separate tracks for freight and passenger transport. 2） The level-crossing accidents in Japan are mostly caused by pedestrian errors. To solve the problem, we build either elevated tracks or tunnels for the level crossings but they are costly. However, we have in place a system in which the government pays 90% and the railway operator pays 10% of the cost.
5	Q	South Africa has also started to pay attention to the environment and place emphasis on sustainability. In terms of the cost to ensure sustainability, what will be the approximate scale of investment needed for the high-speed railway?
	A	Generally speaking, no other high-speed transportation mode is better than the high-speed railway from the viewpoint of cutting CO_2 emissions. The initial investment cost is high but the life cycle cost shall be considered. The Survey Team for the high-speed railway pre-F/S?? has compiled data on the estimated reduction in CO_2 and NO_X emissions. Please request information directly from the Survey Team.
6	Q	Were some of the employees laid off because of introduction of the *Suica* system?
	A	Some had been reassigned but there was no laid off. Rather, the introduction of electronic money made possible by the *Suica* system had a beneficial effect on employment as it facilitated growth of other businesses inside stations.
7	Q	1） How is the universal access situation in Japan? 2） Are there any means of communication between railway users and railway operators in Japan?
	A	1） In Japan, the government has put in place guidelines for people with special needs and railway operators are required to follow those guidelines. Stations with over 5000 users per day must follow the guidelines to provide access to people with special needs, such as by laying yellow lines with vertical dots, etc. 2）All railway operators have services designed for people with special needs. Since such service typically has a dedicated telephone number, people with special needs can dial this number to communicate with the railway operator.

8.5 Results of Questionnaire

At the Railway Conference, the Study Team distributed questionnaires to participants to ask them to evaluate the Conference in general as well as individual presentations. The evaluation results of the Railway Conference and the railway sector study are given below. The three venues had a total of 97 respondents.

8.5.1 Overall Evaluation

Participants of the Railway Conference were asked to rank the overall Railway Conference and the railway sector study results by selecting “Useful,” “Fairly Useful,” “Not Particularly Useful,” or “Not Useful.” Figure 8-1 shows the evaluation of the Railway Conference as a whole and Figure 8-2 shows the evaluation of the railway sector study results. Both received high marks in their evaluation.

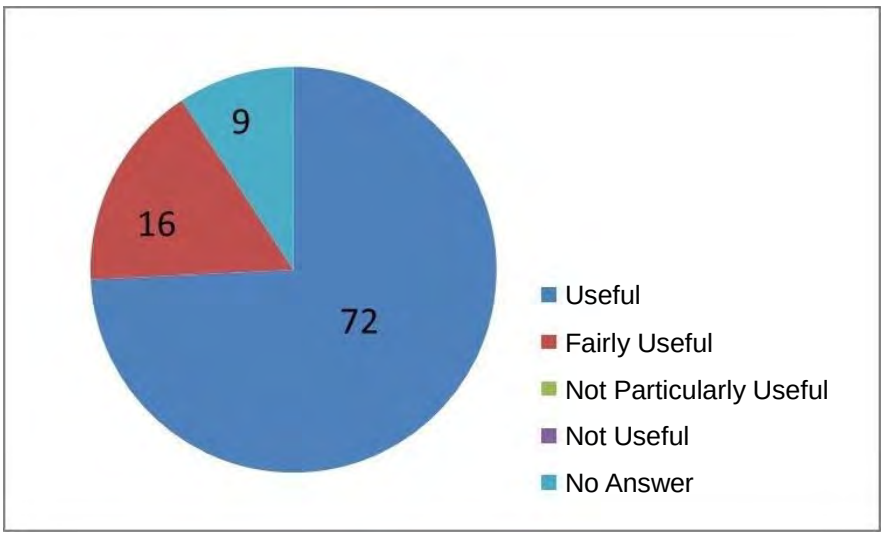

Figure 8-1 Evaluation of the Railway Conference

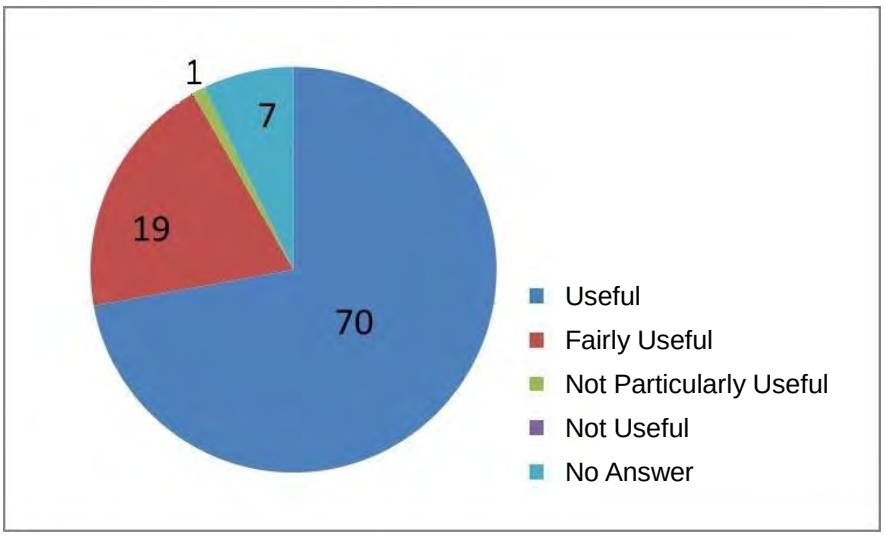

Figure 8-2 Evaluation of the Railway Sector Study

8.5.2 Main Opinions of the Railway Sector Study and Roadmap

(1) Main Opinions of the Railway Sector Study

- The Study discusses the current state of the railway sector in South Africa and a wide range of other topics. It highlights the issues that South Africa shall tackle now and in the future.
- The Study clearly shows the issues faced by the railway sector in South Africa. I believe Japan’s railway technologies can help solve these issues.
- South Africa’s railway system is aging. Modernization of the railway sector necessitates introduction of Japanese railway technologies.

(2) Opinions of Roadmap

- The roadmap presents a vision of the future for the railway sector in South Africa. If the railway can be modernized as described in the roadmap, South Africa will be able to develop world-class railway technology in the future.
- It clearly set forth goals for the modernization of railway in South Africa. It will be a long way to reach these goals but I believe that they can be achieved.
- The roadmap will be very useful when the Study Team makes plans and budgets for the modernization of railway in South Africa.

8.6 Summary of the Outcomes of the South Africa–Japan Railway Conference

8.6.1 Publicize the Advantages of the Japanese Railway System and Enhance Its Presence

Through the presentation of Japanese speakers on the development of the Japanese railway system and its technical aspects, the Conference participants were able to get a good understanding of the superiority of the Japanese railway system. In addition, from the reports of key officials who visited Japan through a JETRO program held prior to the Railway Conference and the report by Professor Ndege of Vaal University of Technology on his inspection of the Japanese railway system, it is clear that experts in South Africa also recognize the excellence of the Japanese railway system.

By deepening the understanding of railway personnel in South Africa about the superiority of the Japanese railway system, the Study Team wase able to increase the presence of the Japanese railway system and enhance the perception that Japan is the best partner to help South Africa modernize its railway sector.

8.6.2 Reaffirm the Strengths of the Japanese Railway System

Among the advantages of the Japanese railway system, the high level of safety and punctuality of the Japanese railway system and Japan's ongoing efforts to improve technical capabilities through training, in particular, seem to have left a strong impression on the South African participants. These attributes are considered common sense in Japan but through this Railway Conference, the Study Team was able to reaffirm the strengths of the Japanese railway system.

8.6.3 Verify the Needs of Railway Development in Each City

The Railway Conference was held in three major cities. Through this Conference, the Study Team was able to confirm the specific needs of each city in railway development, including industrialization of the railway sector for Johannesburg, development of high-speed railway between Johannesburg and Durban for Durban, and further development of urban railway for Cape Town.
In this Survey, the Study Team proposed conducting study for a comprehensive urban development plan that includes study of an airport link for Durban (to be utilized as a high-speed railway line between Johannesburg and Durban in the future) and utilization of AFC for Cape Town. Since these initiatives match the needs of South Africa, it is hoped that these studies will be conducted in the future.

8.6.4 Develop Understanding of Japan's Public and Private Initiatives

In this Conference, initiatives by Japanese companies in South Africa were presented using the example of Mitsui/Toshiba, which jointly helped a local company (UCW) to restore its technical capabilities through technical transfer and job creation. The presentations on the JETRO program to invite key personnel and the JICA assistance schemes conveyed to Conference participants that Japan's public and private sectors are taking a proactive approach to facilitate the modernization of railway in South Africa.

Chapter 9

Summary and Recommendations

Chapter 9　Summary and Recommendations

9.1　Recommendations for the Modernization of the Railway Sector in South Africa

9.1.1　Summary and Recommendations

The following are recommendations for promoting the modernization of railway sector in South Africa and the direction for Japanese assistance based on the findings of this Survey:

(1) Restoring Technical Level

1) Human Resources Development（Maintenance and Manufacturing）

At railway workplaces, more and more veteran engineers and technicians are going into retirement. The succession of technologies has become a problem. During the time when investment in railway was suppressed, many of the mid-level employees who would have become the next generation of engineers and technicians resigned en masse, making it difficult to find successors nowadays. Furthermore, the skills of the newly hired and young employees, who would have been trained by those mid-level employees, have not made much improvement. The vicious cycle fails to bring up new mid-level employees. To break this cycle, railway operators must provide proper human resources training to employees at various levels and restore the technological level.

2) Technical Transfer

TRANSNET and PRASA have announced unprecedentedly large-scale investment plans for the modernization of the railway sector in South Africa. In order to implement these large-scale investment plans, each railway sub-sector (rolling stock, signaling and telecommunications, track, and AFC) will have to deal with the new technologies. How to transfer the technologies owned by foreign countries, including Japan, is a challenge.

(2) Developing Supporting Industries

1) Developing Small-and-medium-sized Companies

Many of the railway-related small-and-medium-sized companies had been in severe business condition. Due to the low level of investment in the railway sector in the last twenty years, the technological level has declined. Many of the qualified engineers and technicians have moved overseas. Some companies are forced to take a second look at the contents of their businesses.

Some foreign companies that manufacture railway component parts have made inroads into the South African market. Most of them are importing main component parts from their own group companies in the world. This does not help to develop local companies in South Africa. It is a problem.

The development of small-and-medium-sized companies requires not only human resources development and technical transfer mentioned above but also financing using low-interest loans, and so on.

2) Increasing Production Capacity

The lack of investment in the railway sector resulted in aging production facilities and inefficient production. For the supporting industries of the railway sector to have stable operation, the existence of stable demand is the first prerequisite. It is important for business operators to improve labor productivity and enhance production capacity. To that end, it is necessary to improve the quality of workers through human resources development and at the same time, introduce high-quality capital (production facilities) with high production efficiency.

(3) Promoting Localization

1) Promoting Localization based on (1) and (2) Above

At present, the South African government is promoting localization, which is also viewed as the most important criterion in bidding. For foreign companies, localization has become the biggest barrier when they expand business or make entry into South Africa. European and U.S. companies that have already made inroads into South Africa and have set up production facilities are responding positively because localization will require relatively little additional investment from them. On the other hand, for companies that do not have production facilities in South Africa, they are struggling to find ways to deal with the burden of high cost.

South Africa shall take note that if it places too much emphasis on promoting localization, it risks not being able to introduce the advanced technologies that it needs and that it might not be able to bring up businesses that are competitive enough for the world market in the future. For foreign companies, it is important to not only strengthen the collaborative structure of localization but also continue to make efforts to explain why it is necessary to introduce their advanced technologies to South Africa from a long-term perspective.

2) Becoming a Leader of Southern Africa in the Railway Industry sector

It is important to develop the railway industry into an industry not only for South Africa but also for Southern Africa in the future. To that end, it is important to first develop companies so that they have technologies more advanced than the technical capabilities that they had twenty years ago and to form railway industrial clusters in South Africa. Next, rather than having a near-sighted view for the modernization of railway, it is important to envision a future railway industry with a wider perspective, one that looks up to the diverse services, facilities, and urban development of the world's railways so that South Africa can become the center of railway industry in southern Africa. Then, it is important for South Africa to bring into existence a new railway (future image) and become the driving force for its neighboring countries.

(4) Direction of Japanese Assistance

1) Dispatch of Experts by JICA

Human resources development/education and training are an important issue in pursuing modernization of the railway sector in South Africa. The Study Team believes that it is effective to dispatch human resources development experts of the railway field to the Department of Transport, which implements railway policies in South Africa, on a long-term basis in order to support this important policy issue. Since rolling stock, signaling and telecommunications, track, and AFC are the areas where Japanese technologies can be utilized in South Africa, it will be desirable to send groups of experts specializing in specific areas at that time.

The following are contents of main technical guidance:

・Support establishment of the Faculty of Railway Engineering at Vaal University of Technology in Gauteng province

・Strengthen the functions of the School of Engineering under TRANSNET

・Cooperate with the Training Academy of PRASA

2) Comprehensive City Development Study (Preparatory survey)

Japanese urban railways have been developed as railway systems characterized by automatic ticket gates, smart card tickets, business development inside train stations, and connection with other transport modes at stations. To take opportunity of the large-scale procurement of EMUs by PRASA to replace its aging trains, the Study Team can propose a railway system to facilitate functional urban development with focus on the urban railway. This can promote understanding of the Japanese railway and increase the chance of introducing Japan's urban railway system to South Africa. Cape Town, in particular, has strong interest in urban transportation planning,

including urban railway. It is a city suitable for conducting a comprehensive city development study.

3) Private Sector Investment Finance (PSIF)
As already pointed out in this report, railway-related projects in South Africa have certain risks, including the risk of project delay. Nevertheless, companies from other countries are actively making efforts to participate in railway-related projects in South Africa. Competition, including cost, is becoming more intense. Furthermore, since South Africa can become a base for the southern African region, it is a strategically important country not only to railway-related businesses but also to Japanese companies. In view of this viewpoint, and to encourage Japanese companies to make entry into South Africa, the Japanese government shall use overseas investment schemes to provide financial support to Japanese companies that are planning to make entry into South Africa.

9.1.2 Technologies Required for the Modernization of Railway Sector in South Africa and Superiority of Japanese Railway Technologies

When introducing Japanese railway technologies to South Africa, the railway technologies must be superior compared to those of the other countries. Furthermore, they have to meet the needs of the modernization of railway sector in South Africa. From this viewpoint, the Study Team organized the Japanese railway technologies and listed them below according to their priorities.

(1) Urban Railway System

It is believed that South Africa needs integrated transport. Integrated transport refers to not only the railway but also urban development plans that will enhance the connectivity with other transport modes at the station, residences in the station vicinities, and commercial development. Furthermore, as stated in the feasibility report of the PRASA rolling stock investment program, transit-oriented development is expected to draw population to the station areas and drastically increase the number of railway passengers in the future.

In relation to this, Japanese urban railways have been developed as an integrated railway system that includes automatic ticket gates, smart card tickets, business development inside train stations, and connection with other transport modes at stations. Japan excels in this area and it can fulfill the needs of South Africa mentioned above.

(2) Rolling Stock

Using the low-maintenance, lightweight AC electric motor as the main motor for rail cars is common sense since long time ago. In addition, Japan has achieved both high operation performance and drastic reduction in energy consumption by using the latest control technology and the latest design and manufacturing technology to produce lightweight car body and bogie structure with great strength. As an example, compared to the standard Series 205 commuter trains of about 20 years ago, the latest model of the Series E233 JR East commuter train consumes approximately 30% less energy.

While improving reliability, Japan has devoted a long time to validate and achieve low-cost maintenance by extending the cycle and simplifying the contents to optimize maintenance. Such effectiveness is made possible also by the high reliability and durability of vehicle parts. Such characteristics of the Japanese rolling stock technology are essential to the success of large-scale introduction of new rolling stock in South Africa.

(3) AFC

For a railway to have stable operation, it is necessary to have more people use the railway in order to ensure revenue. Therefore, in addition to modernizing railway facilities, it is important

to make the system easily accessible from the point of view of the users.

In Japan, JR East introduced the Super Urban Intelligent CArd (Suica) in 2001. This automatic fare collection (AFC) system uses IC card instead of paper tickets. Compared to similar systems in other countries, the Japanese AFC system has particularly high processing speed. The system is most suitable for a commuter railway that has high concentration of passengers within a short period. It can also be used for other railway companies and bus routes using the same system. Besides having the function as a train ticket, the IC card can be used for shopping at the stations and in the city. Due to its convenience, the number of users is rising every year.

One of the strategies to promote the use of railway in South Africa in the future is to build a new urban transport system that integrates public transport modes, such as commuter trains and buses. There is great possibility for utilizing the advantages of the Japanese AFC system because it is extremely convenient to the users.

(4) Track

TRANSNET is aiming to increase the transport volume of freight and PRASA is aiming to improve the safety of passenger transport by introducing new rolling stock and modernizing facilities. In the future, track maintenance will become increasingly important in helping to achieve these goals. However, TRANSNET and PRASA do not have sufficient track maintenance technology. It is essential that they improve their track maintenance technology. At the same time, it is also important to lower the track maintenance cost by introducing technologies that can mitigate track maintenance work and using durable track materials.

Japan has advanced technology in track maintenance. It also has technology to construct low-maintenance track (slab track) that can contribute to the reduction of track maintenance cost and technologies to manufacture highly durable rails and compound sleepers. These technologies can contribute to the modernization of the railway sector in South Africa.

Compared with the ballast track, the initial construction cost of slab track is more expensive. However, its maintenance cost is low due to little need for maintenance. Compound sleeper has similar durability as the prestressed concrete sleeper (50 years of durability life). In addition, Japan has developed rail that has the highest level of resistance in the world against abrasion and damage caused by internal fatigue.

(5) Signaling and Telecommunications

The three kinds of technologies necessary for the modernization of the railway sector in South Africa are: 1) introduction of Automatic Train Protection System (ATP), 2) introduction of traffic control system, and 3) strengthening of measures to enhance maintenance. With respect to ATP, the functional specification and performance are essentially the same when comparing the Japanese system with the European system. When comparing the European method with the Japanese method of the traffic control system, their basic functions, such as rescheduling after the disruption of traffic control and train operation, are equivalent. However, the Japanese system is superior in functions that can support regulated train operation due to disasters caused by earthquake, rain, wind, etc.; secure interval for maintenance work in a high-density timetable environment, and prevent trains from entering into closed sections.

The three kinds of technologies necessary for the modernization of the railway sector in South Africa are: 1) introduction of Automatic Train Protection System (ATP), 2) introduction of traffic control system, and 3) strengthening of measures to enhance maintenance. With respect to ATP, the functional specification and performance are essentially the same when comparing the Japanese system with the European system. When comparing the European method with the Japanese method of the traffic control system, their basic functions, such as operation adjustment after the disruption of traffic control and train operation, are equivalent. However,

the Japanese system is superior in functions that can support regulated train operation due to disasters caused by earthquake, rain, wind, etc.; secure interval for maintenance work in a high-density diagram environment, and prevent trains from entering into track closure sections.

9.2 Challenges to Review in the Future

There are several important challenges for the modernization of the railway sector in South Africa, including restoring the technological level, developing human resources, transferring technology, developing supporting industries, and promoting local production. Under such circumstances, in order for South Africa to use the Japanese railway system, it is necessary to enhance its understanding of the advantages of Japanese railway technologies, transfer technology, and provide expertise in the planning, implementation, and operation of urban railways and high-speed railway in the future.

The following are matters that shall be addressed based on the current state and issues of the railway sector in South Africa identified through this Survey and the intention of the DOT.

(1) Promote Understanding in the Superiority of Japanese Railway Systems

The Japanese railway technology has been developed along two major axes: high frequency commuter transport in cities and high-speed railway, that is, high-capacity/high-speed transport by shinkansen. The pursuit of speediness and accuracy through these developments results in the advancement of operational technologies, including an optimal signal system for each form of transport. In addition, improvement to the power system of rolling stock and lightweight car body has reduced the energy consumption of trains, minimized the scale in the expansion of power facilities, and reduced the cost of track maintenance. Besides speediness and accuracy, ensuring the safety of transport is the highest priority. In addition to introducing new facilities, Japan continues to devote efforts to appropriate maintenance in order to ensure safety and clarify the quantitative limit in the use of each element.

It is important to promote understanding of the advantages of these Japanese railway systems through training programs in Japan.

(2) Review Plans for Dispatching Experts

In order to promote understanding of the superiority of the Japanese railway systems mentioned in (1) above, it is effective to dispatch railway experts from Japan with a view to facilitating human resources development of the railway sector in South Africa. The areas of specialties of the experts and the timing of the dispatch shall be further reviewed. In particular, since the experts (experts in the development of human resources for railway) to be sent to DOT for long-term stay will need to handle multidisciplinary tasks, it is effective to send them in groups by their specialty area. The areas of expertise and dispatch plans shall be fully reviewed. When sending experts to PRASA and TRANSNET for short-term stay, it is desirable to send experts in the fields of railway technology in which Japan has an advantage.

(3) Review Human Resources Development and Training Programs

It is necessary to review human resources development, training programs, and curricula for strengthening the functions of the School of Engineering under TRANSNET and the Training Academy under PRASA. There is a need to review especially the methods for technical transfer in order to promote understanding among the working-level personnel and young engineers in the Japanese railway systems (urban railway and shinkansen). To that end, it is possible to take advantage of the training schemes offered by JICA, related organizations, and businesses in Japan.

(4) Detailed Study of Related Industries (Supporting Industries)

There is a need to clarify the technologies necessary for the railway industry of South Africa in the future and re-examine in detail the methods of cooperation, including the feasibility of technical transfer.

To do so, it is important to utilize the UNIDO data with the cooperation of the South African government to obtain detailed data on railway-related industries in South Africa and make hypothetical business matching.

(5) Establishing a System for Japanese Companies to Make Market Entry

As described above, it is important to perform hypothetical business matching using the UNIDO data to review in detail the possibility for Japanese companies to make entry into the market. It is also important to review the system for making market entry, such as making entry through collaboration with beneficial partners, role sharing with local partners, and so on in order to develop model cases.


JICA