Hanoi City People's Committee

Japan International Cooperation Agency

Rolling Stock Maintenance Manuals

TA PROJECT TO STRENGTHEN THE CAPACITY OF REGULATOR AND TO ESTABLISH OPERATION AND MAINTENANCE COMPANY OF METROPOLITAN RAILWAY LINES IN HANOI CITY

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Hanoi, November 2015

Rolling Stock Maintenance Manuals

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1) Legal Basis and Reference

1.1 Legal Basis

- Railway Law
- Circular No. 02/2009/TT-BGTVT, Circular No. 36/2011/TT-BGTVT by MOT and other related regulations: Regulations on inspection of quality, technical safety and environmental protection for railway vehicles
- Circular No.21/2015/TT-BGTVT on working hours and break time of employees who engage in specific operations in railway transportation.

1.2 Reference

- Decree No. 114/2004 and No. 46/2015/NĐ-CP dated on 2015/5/12 on quality control and maintenance of structural objects.
- Circular No. 20/2013/TT-BGTVT dated 2013/8/16 on management and maintenance of railway structure.
- Circular No. 15/2009/TT-BGTVT on response to railway accidents and incidents.
- General technical regulations concerning urban railway operation and maintenance (Draft)
- Basic design of urban railways 2, 2A and 3 lines
- Experience and knowledge regarding preparation of train allocation plan, maintenance personnel calculation, renew, purchase of new trains, budget preparation, training method, how to deal with accidents, etc. at Tokyo Metro.
- Regulation dated 2015/8 on railway operation.
- Line-2A (Cat Linh-Ha Dong) Training Plan Ver. 16.0.

2) Purpose and Definitions of Manual

2.1 Purpose

The purpose of this manual is to instruct personnel in practical rolling stock maintenance including how to create the train allocation plan, how to calculate the number of necessary maintenance personnel, how to implement renewing/restoring and new rolling stock procurement, budget preparation procedures, training methods, regulation revisions, how to operate and manage Maintenance Center, and how deal with accidents.

2.2 Definitions

a. Train allocation

Train allocation denotes allocation of trains to be operated on a daily, monthly and annual basis to implement the periodic maintenance.

b. Maintenance budget

A rolling stock maintenance budget is prepared for the rolling stock maintenance work in consideration of the workload, unit price and comparable standards in the implementation plan.

c. Maintenance personnel

Maintenance personnel refers to the people who are directly engaged in the maintenance work in the specific place of maintenance.

d. Renewal

Renewal is changing performance of rolling stock, or changing the structure or specifications of a main motor, bogie, brake system, coupler or car body from the initial design.

e. Railway traffic accident

A railway traffic accident is a problem caused by railway transportation means that gives damages to human life or health, or property as a result of collision, derailment, over-turning or bursting into flames. A collision in this context includes that with people, other transportation means and obstacles.

f. Incidents in urban railway

It is a problem that occurs in the transportation activities of the urban railway. It is not categorized as a railway accident though it affects the railway operation.

3) Train Allocation Plan Preparation Procedure

This includes allocating trains for operation and inspection to be implemented on a daily, monthly, quarterly and annual term basis, and the operation plan and other maintenance plan.

3.1 Principle of Train Allocation for the Inspection that is Implemented on an Annual, Monthly and Daily basis

- Ensuring the train operation plan.
- Implementing the inspection within the specified periods and train operation kilometrage.
- Equalizing the workload to minimize the number of personnel throughout the entire period.
- Equalizing kilometrage of each train at the planning stage.
- Ensuring sufficient time for cleaning, wheel grinding, training, and other tasks.
- Ensuring safety during maintenance, and effect of cost and quality in the train allocation.

3.2 Preparation Procedure of Train Allocation in Inspection Periods that is in Accordance with Workload in Respective Maintenance

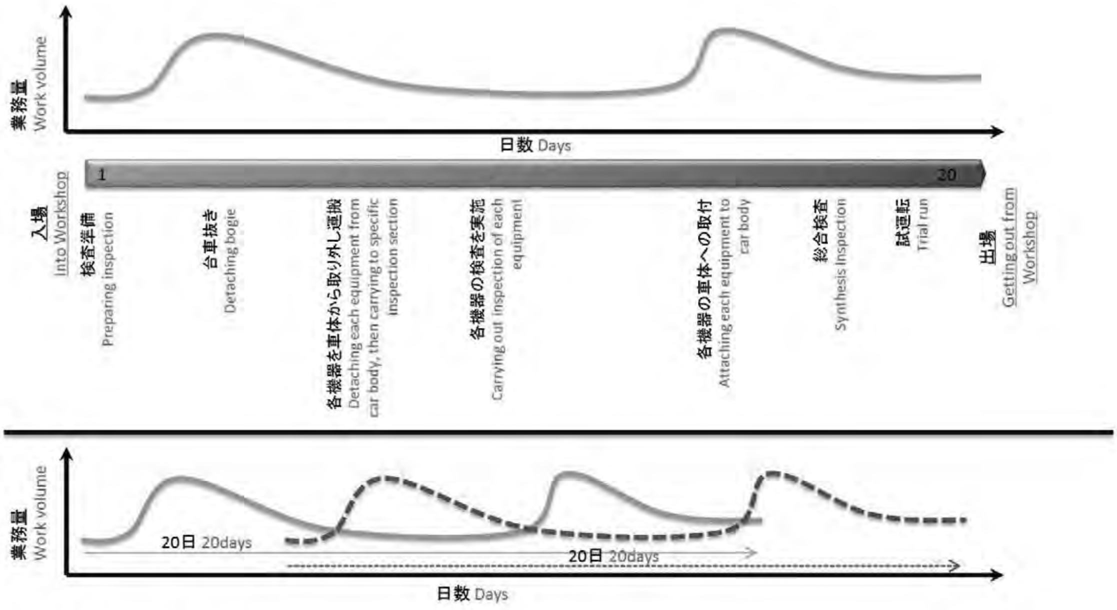


Figure1: Outline of Maintenance Workload in Medium Repair

(Source: Tokyo Metro)

Figure 1 describes the workload in of the medium-scale repairs carried out by at Tokyo Metro. Although the total maintenance implementation period is 20 days, workloads vary depending on the day (same as above). An "Equalizing" approach is employed by Tokyo Metro in order to secure the required work progress, equalize the maintenance workload, and enable rolling stock maintenance personnel to fulfill their abilities as shown in the figure.

However, workload may not be so large when HMC starts the operation. Since maintenance personnel for medium- and large-scale repairs are not included in Line-2A training program at the start of the operation, it may not yet be necessary to introduce train allocation based on "equalizing" as shown in Figure 2. After multiple lines are opened in the future, workload will be increased along with an increase in train kilometrage and the number of trains targeted for periodic maintenance. At that point, HMC may study whether to allocate trains based on the above approach.

3.2.1 Train Allocation in Medium- and Large-Scale Repair

- The train allocation preparation method described in this manual is based on the hypothesis developed by Tokyo Metro.
- Medium- and large-scale train repairs are conducted in four-year and eight-year inspection.
- Two types of train allocation are employed for medium- and large-scale repairs. One is a centralized approach, and the other is a distributed approach (allocated evenly in the period) as shown in the figure below.

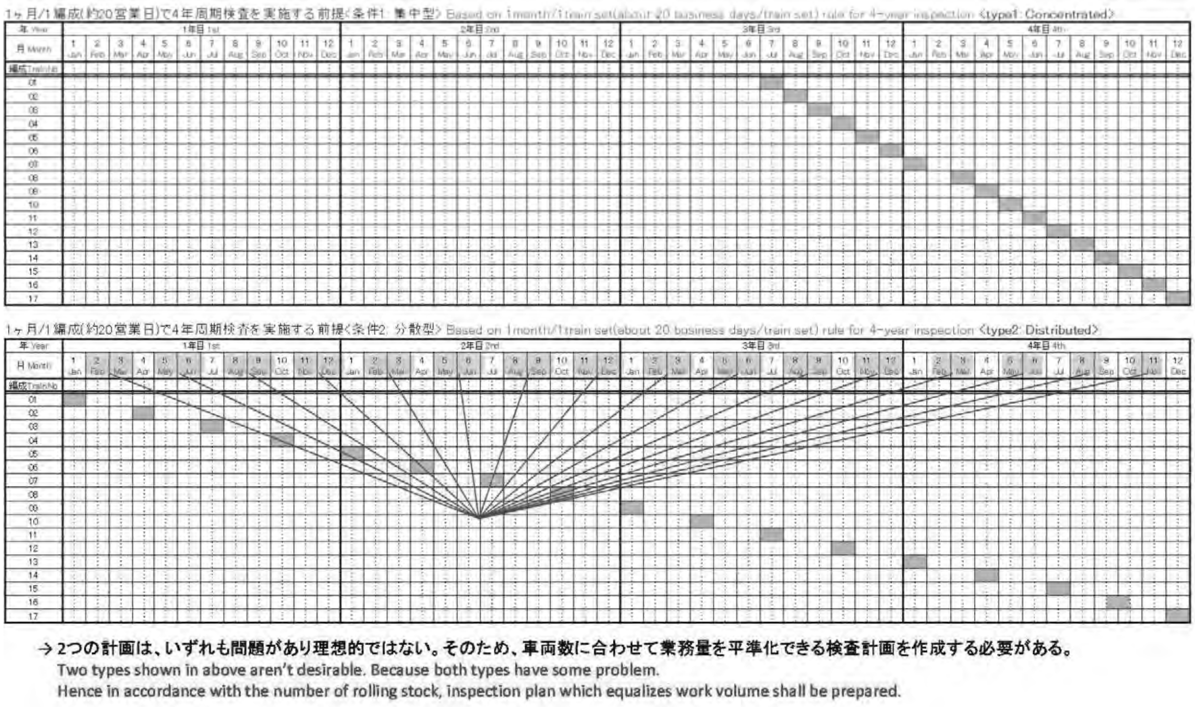


Figure2: Train Allocation for Medium- and Large-Scale Repair

- The approach you should choose depends on initial factors existing at the time the plan is created such as personnel, costs, training, and other work plans.
- In the train allocation for medium- and large-scale repairs carried out by Tokyo Metro, where the lines and maintenance personnel are stabilized, the workload is evenly allocated to each period every year as shown in the above figure.
- Allocating an even workload in the annual maintenance plan provides the following advantages.

Number of personnel	- It allows averaging of the workload at each phase, so you can minimize the number of personnel required. - It allows averaging of the maintenance budget at each phase.
Work quality	- It provides opportunities for personnel to gradually gain and enhance their knowledge and skills (in particular at a new company).

- There are no personnel for medium- and large-scale repairs at HMC in the initial stage according to training program for opening. In the initial stage, train maintenance can be carried out in accordance with the manufacturer's regulations. Since there is no demand for medium- or large-scale repairs at the initial stage, a medium-scale repair should be carried out at least four to five years in the future. Therefore, it is not possible at this stage to develop a plan to allocate the same workload each year for medium- or large-scale repairs. Thus, the initial maintenance plans should be concentrated in the final phase of the periodic maintenance period as shown in the lower figure in Figure 2.

- If inspection personnel can be hired stably for maintenance work once, the next step is to develop train allocation for the next and later medium-scale repairs in such a way that the same workload is allocated each year. See the upper figure in Figure 2.
- In order to ensure an appropriate allocation, the requirements for creating the daily and monthly plans should be determined in consideration of the periods of large-scale repairs, medium-scale repairs, daily and monthly maintenance (see the example below for details).

a) Train Allocation Preparation Method

For example, when the period of medium-scale repairs is four years and that of large-scale repairs is eight years for 11 train sets:

The average number of train maintained (each maintenance) is as shown below.

8 years: 11 train sets/8 years = 1.4 ≈ 1 to 2 train sets/year

4 years: 11 train sets/4 years = 2.75 ≈ 2 to 3 train sets/year

3 months: 11 train sets/3 months = 3.66 ≈ 3 to 4 train sets/month

6 days: 11 train sets/5 days = 2.2 ≈ 2 to 3 train sets/day

The necessary time per train is set as follows to average the workload.

8-year inspection: 96 months / 11 train sets = 8.7 months/train set

4-year inspection: 48 months / 11 train sets = Approximately 4.4 months / train set -> Approximately 4.5 months / train set

3-month inspection: 90 days / 11 train sets = 64 business days / 11 train sets = 5.8 business days / train set -> 6 business days/train set

6-day inspection: 6 days / 11train sets = 0.54 days/train set

■ Thus, the result of the study was as shown below.

8 years: 1 to 2 train sets / year

4 years: 2 to 3 train sets / year

3 months: 3 to 4 train sets / month (Inspection day 6 days/train set)

6 days: 2 to 3 train sets / day

However, the above average number of trains is for managing the workload of medium- and large-scale repairs. When creating a plan to evenly allocate the workload as shown above, some troubles may emerge. Because operation of 11 train sets is started at almost the same time, their planned maintenance period will be virtually identical. Thus, the implementation as shown in the above calculation will not be able to be used. At VNR, maintenance management is carried out based on the kilometrage. So, when calculating the number of the locomotives/trains to be maintained, they convert actual kilometrage or planned kilometrage (train operation diagram) of every train on every line calculated from the day, month and year to the corresponding maintenance period-based kilometrage to classify the locomotives/trains. In order to evenly allocate the workload, they allocate trains unevenly by adjusting the specific train operation program. In this way, they prevent occurrences of trains having the same maintenance and repair periods at a time.

The following shows the formula used to calculate the number of locomotives/trains on which large-scale repairs are conducted in a year.

$n_o = \frac{L_{\Sigma}}{L_{CKD}}$, locomotive/trains (Lckd: Kilometrage of the large-scale repair period)

The following shows the number of locomotives/trains on which medium-scale repairs are conducted in a year.

$$n_T = \frac{L_{\Sigma}}{L_T}\left(1 - \frac{L_T}{L_D}\right)$$, locomotives/trains

Where,

L_{Σ} : Total of kilometrage of every train on all lines in a year, km

$L_D, L_T, \ldots$ - Kilometrage-based maintenance cycle of medium- and large-scale repairs

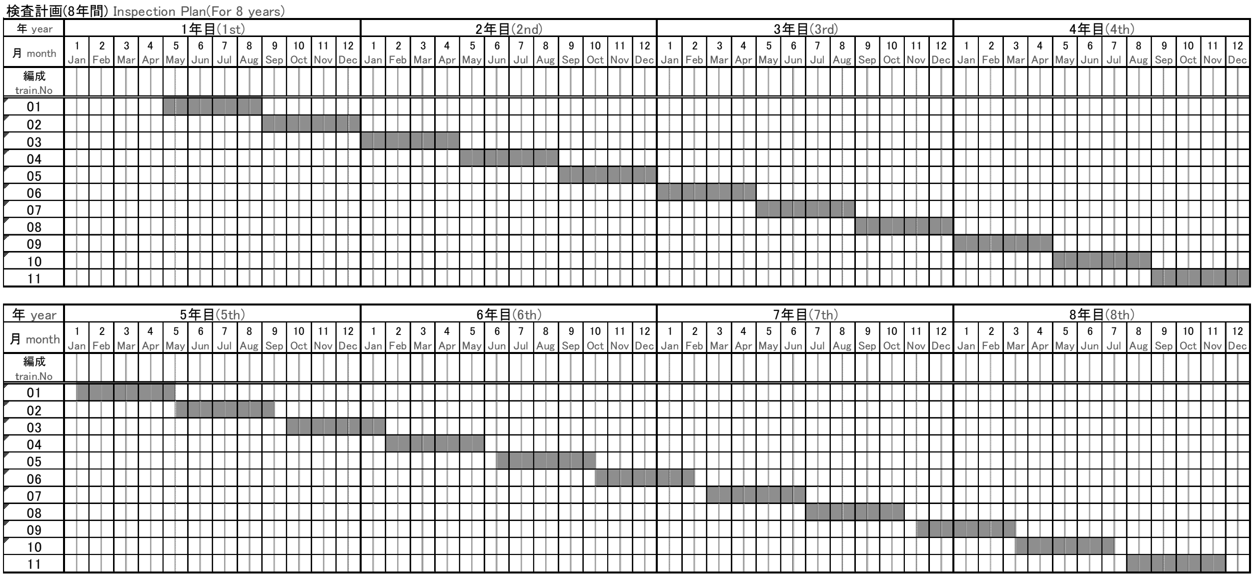
When a train's kilometrage is 150,000 km/year, for example, the number of trains targeted for medium-scale repairs conducted every four years calculated based on the above formula is as shown below.

nD = 150,000*11 / 1,200,000 = 1.37 (1 to 2 trains / year)

1,200,000 indicate the inspection period 1,200,000 km for medium-scale repairs of Line-2A.

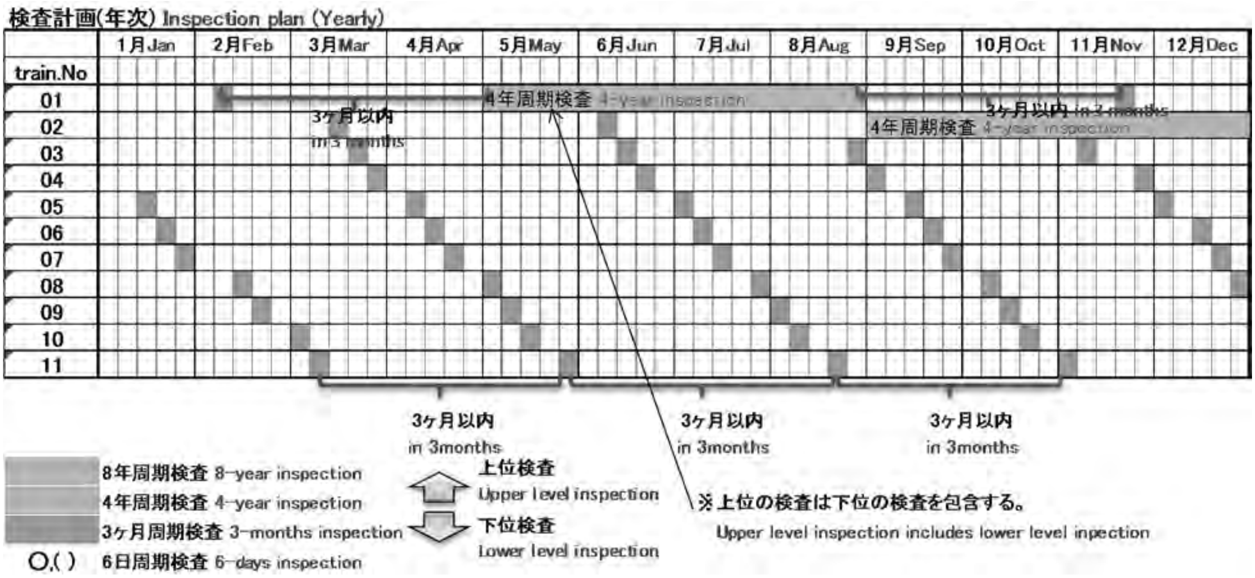
However, it is necessary to consider and manage the possible cases where occurrence of equipment failures installed in such trains will be earlier due to the increased travel distance, which may affect the operation plan compared with other trains. It is necessary to manage the devices and equipment which require inspection, maintenance and repairs based on the kilometrage (such as wheel grinding, brakes, etc.)

\+ Train allocation for 4- and 8-year maintenance



+ Annual plan

- Work of periodic 4-year maintenance is included.



+ Monthly plan

- It includes the work within a month as well as cleaning and wheel grinding and trains targeted for periodic maintenance of 8 years, 4 years, 3 months and 10 days.

- For 10-day maintenance, prepare a plan with an approximately 7 to 10 day.

- The planned 10-day maintenance period, cleaning and wheel grinding are implemented after the train operation time.

- Regarding 3-month maintenance, check whether it is possible to carry this out on weekdays during daylight hours.

- Based on the annual medium- and large-scale repair plans, prepare the corresponding daily and monthly plans as described below.

検車区 Inspection yard		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
	3月 3months		08							09							10														11	
	6日6-days		10	04	06	03	02	11	04	06	05	02	04	06	07	05	02	06	03	05	08	02	06	03	07	04	02	09	03	07	04	02
			11	09	07	05	10			07	08	10	11	03		08	04	11	09	07	04		11	09	08	10	06	11		08	10	06

検査計画(月次-編成番号での整理) Inspection plan (Monthly - train No. base)

編成 Train No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
5月 Mar	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T
01																															
02	A	G	G	B	C	( )	I	C	B	A	(H)	G	E	E	D	( )	A	G	F	D	( )	C	C	B	A	(H)	F	H	E	E	( )
03	B	A	D	F	( )	D	D	I	F	E	F	E	( )	F	E	B	B	(H)	G	E	E	D	( )	C	B	A	G	( )	F	F	D
04	C	B	( )	G	G	E	E	( )	C	B	A	(H)	F	G	F	(H)	G	E	D	( )	F	E	D	D	(H)	B	A		G	( )	F
05	D	C	A	A	(H)	F	F	D	D	(H)	B	A	G	H	( )	C	C	A	(H)	F	G	F	I	I	I	I	I	A	H	G	G
06	E	D	B	(H)	A	G	G	E	(H)	C	C	B	(H)	I	G	D	( )	B	A	G	H	( )	E	E	C	( )	B	B	A	I	(H)
07	F	E	C	( )	B	A	H	F	( )	D	D	C	A	( )	I	E	D	C	( )	A		G	F	(H)	D	C	C	C	( )	A	I
08		I	I	I	I	I	A	G	E	( )	E	D	B	A	(H)	F	E	D	B	(H)	A	H	G	( )	E	D	D	D	( )	B	A
09	G	F	(H)	C	D	B	B	H	I	I	I	I	I	B	A	G	F	( )	C	B	B	A	(H)	F	F	E	( )	E	B	C	B
10	H	(H)	E	D	E	( )	C	A	G	F	( )	F	C	C	B	I	I	I	I	I	C	B	A	G	( )	F	E	F	C	(H)	C
11	I	( )	F	E	F	C	( )	B	A	G	G	( )	D	D	C	A	( )	F	E	C	D	( )	B	A	G	G	(H)	G	D	I	I

検査周期の確認(11編成の例) check the inspection period (In case for No.11 as an example)

清掃 cleaning: 10日10days 10日10days 10日10days → 10日以内OK in 10 days OK

6日 6-days inspection: 5日 5days 5日 5days 5日 5days 5日 5days 5日 5days → 5日以内OK in 5 days OK

(H) H運行(6:20～9:40)の後、6日周期検査を実施
meaning; After operating 'H'(6:20-9:40), 6-day inspection will be implemented

I I運行(6:00～9:00)の後、3ヶ月周期検査を実施
meaning; after operating 'I'(6:00-9:00), 3-month inspection will be implemented

	種類 Kinds of maintenance	前提 Precondition
	4年又は8年 4-year or 8-year inspection	<施工に1編成4ヶ月><It takes 4month/train>
	3ヶ月 3-month inspection	<施工に1編成5営業日><It takes 5business-day/train>
( )	6日 6-day inspection	<施工に1編成1時間, 1日1～2編成><It takes 1hour/train, feasible 1～2train sets/day>
	清掃 Cleaning	<10日以内に実施><施工に1編成3時間, 1日1～2編成><Implement in 10days><It takes 3hour/train set, feasible 1～2train sets/day
	車輪削正 Wheel grinding	<12ヶ月以内に実施><1日に2両施工可能><Implement in 12month><feasible 2cars/day>
(空白blank)	予備車 Spare train	

+ Daily maintenance and train allocation plan

Describe the commercial trains to be operated, rolling stock maintenance and other work on a daily basis. The location where maintenance will be carried out and the departure and arrival locations are also included. This is reference material concerning the train allocation to be submitted to the Train Operation Department.

日付 Date	02/May
曜日 Day of the week	Mon

翌日は清掃なので、到着番線は洗浄線
Next day is pland washing, so the arrival track is scheduled to washing track

運行番号 Operation No.	編成番号 Train No.	出庫番線 Departure track No.	出庫時刻 Departure time	一時到着番線 Temp-arrival track No.	一時入庫時刻 Temp-arrival time	再出庫番線 Re-departure track No.	再出庫時刻 Re-departure time	最終到着番線 Final arrival track No.	最終入庫時刻 Final arrival time
A	03	#01	5:00	–	–	–	–	#04	22:00
B	04	#02	5:10	–	–	–	–	#26	21:00
C	05	#03	5:20	–	–	–	–	#01	21:30
D	06	#04	5:30	–	–	–	–	#02	22:30
E	07	#05	5:40	#01	10:00	#01	16:00	#03	23:30
F	09	#06	5:50	#02	9:45	#02	16:15	#08	23:50
G	02	#07	6:10	#30	9:30	#30	17:00	#07	23:00
H	10	#08	6:20	–	–	–	–	#22	9:40
I	08	#09	6:00	–	–	–	–	#21	9:00
予備 Spare	11	#25	–	–	–	–	–	#23	–

保守実施中 Under maintenance	編成番号 Train No.
8年 8-year	–
4年 4-year	01
3ヶ月 3-month	08
6日 6-day	10,11
清掃 Cleaning	11
車輪削正 Wheel grinding	02

一時入庫～再出庫までの間、車輪削正は実施可能
The time between temp-arrival and re-departure, wheel grinding can be implemented

6日検査と3ヶ月検査は、ピット線で実施
6-day and 3-month inspection are implemented at pit track

清掃は、洗浄線で実施
Cleaning is implemented at washing track

車輪削正は、車輪削正線で実施
Wheel grinding is implemented at wheel grinding track

番線情報(仮定) Track information(hypothesis)

#01～#15	留置線 Train storage track
#21～#24	ピット線 Pit track
#25～#29	洗浄線 Washing track
#30	車輪削正線 Wheel grinding track

+ The Line-2A maintenance plan

Average number of trains maintained:

1-month: 13 train sets / 30 days = 0.43 train sets/day, or 30 days / 13 train sets = 2 days/train set

1-day: 13 train sets / day

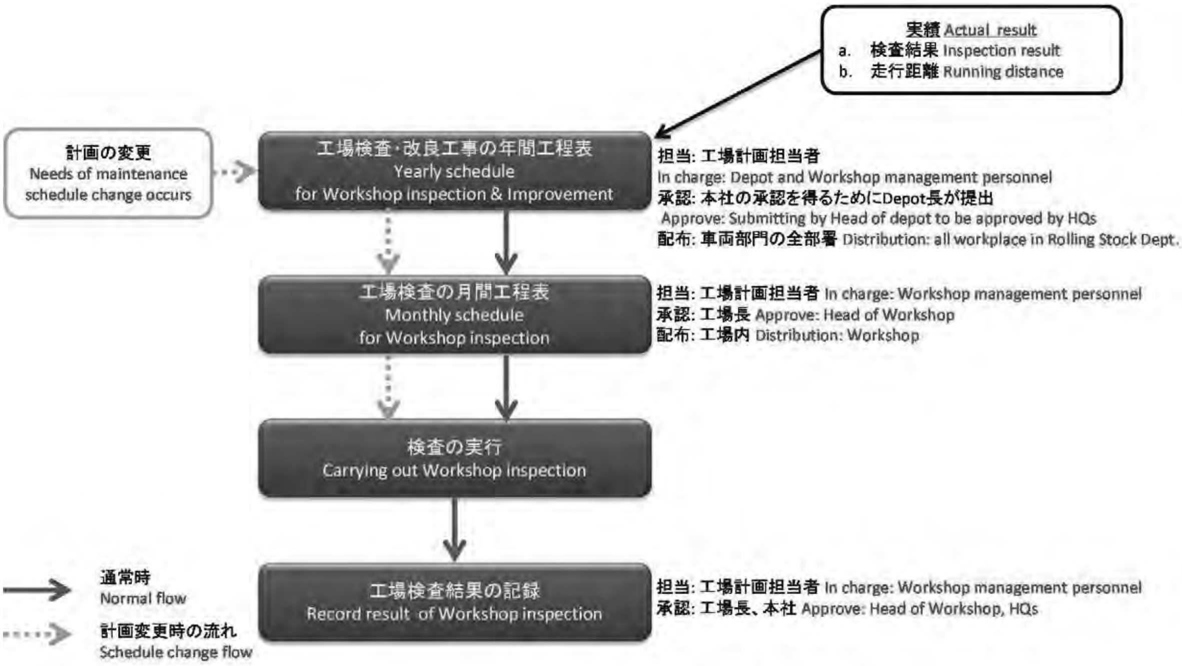
5 days: 13 train sets / 5 years = 2.6 train sets / year

10 days: 13 train sets / 10 years = 1.3 train sets /year

The train allocation includes a plan for train cleaning, wheel grinding and other maintenance work. (For the train allocation of Line-2A, see Attachment 1.)

3.3 Preparation and Approval of Train Allocation

3.3.1 The process in which the plan is created and rolling stock maintenance is implemented at the Workshop.



- Prepare the annual plan based on the long-term maintenance plan (4 to 8 years, and 10 years) of the company.
- Daily and monthly work plans at the Workshop for each line are carried out in accordance with the maintenance manual, which is prepared based on the specifications of each line. The Head of Workshop and management personnel are responsible for handling sudden events that can occur on a daily basis. Depending on circumstances, such events may be reported to the Head of the depot (see below) in order to receive their opinion. After approving the monthly plan, the Head of the Workshop reports on it to the Head of depot.

Detailed procedures are as described below.

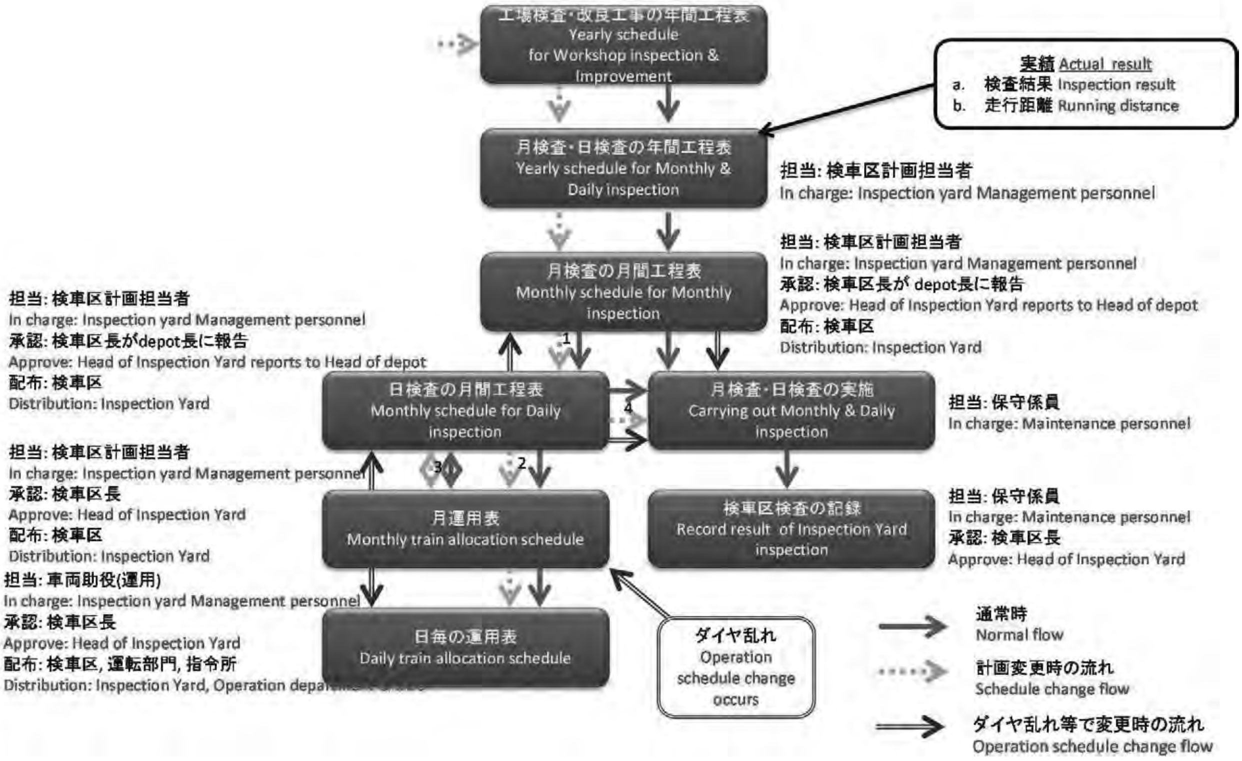
- Step 3: After the annual plan has been approved, the Workshop Management personnel announces the plan to the personnel and concerned parties of the Workshop and Inspection Yard, and allocate the work among them.

- Step 9: After the maintenance work is completed at the Workshop, the Head of Workshop checks the result and current condition of the trains, and decides to put the trains into operation as planned.

- Step 10: After the maintenance is completed, the Head of Workshop reports on the results of implementation to the Head of the depot to receive their approval.

- Step 11: The Workshop Management personnel has responsibility to consider next train allocation based on the inspection period and current results.

3.3.2 Flow of preparing train allocation at Inspection Yard (Maintenance Center)



- Monthly train allocation: Based on the approved annual plan, the Inspection Yard prepares the detailed monthly train allocation. The Inspection Yard prepares the daily and monthly inspection plans along with other maintenance plans, and submits them to the management personnel in Maintenance Implement division in OU to receive their approval. The monthly inspection plan and the train allocation must be approved at least 10 days before the implementation date.

The following shows the flow of preparation, approval and implementation of the monthly inspection plan.

- The head of the Inspection Yard (Maintenance Center) checks appropriateness of putting the trains into operation as planned after the monthly inspection in consideration of the inspection result report. The Inspection Yard is responsible for reporting on the monthly inspection result and the weekly condition of trains to the Head of the depot.
- Daily plan: Based on the monthly plan, the Inspection Yard Management personnel has a responsibility of preparing the detailed daily plan. The approver is the Head of the Inspection Yard (Maintenance Center). The daily train allocation must clearly express the work to be implemented, location and trains.
- The daily train allocation must include the details, and must be approved at least one day before the implementation date.

Preparation of daily maintenance plan

- Daily train allocation to be sent to the Operation Section and OCC: The daily train allocation (based on the monthly train allocation) prepared in accordance with the daily operation plan must be sent to the Operation Section and OCC at least one day before the implementation. If any changes or adjustments are made, they must also be reported promptly.

3.3.3 Plan Modification Process

If any incidents or accidents occur, an already prepared train allocation may be changed in accordance with the actual situation.

In consideration of such a case, the train allocation change process should be prepared in advance. Its procedure conforms to the above procedure.

a. Change in daily plan

The Head of Inspection Yard (Maintenance Center) or Head of Workshop may adjust the daily train allocation or work plan in their charge if such an adjustment will not affect the monthly plan or incur any cost.

b. Change in monthly plan

The Head of Inspection Yard (Maintenance Center) or Head of Workshop may review and adjust a monthly plan, and report on it to the Head of the depot if such adjustment does not affect the overall annual plan and does not exceed the approved budget target.

c. Change in annual plan

OU may review and approve the change and report on it to the Manager of the Rolling Stock Maintenance Management division in HQs if such change does not exceed the approved budget target. Even when the budget target is exceeded, OU must submit it to HQs for their review.

3.4 Rolling Stock Maintenance Management at HMC

In the early stage of the operation (2015 to 2020), HMC plans to carry out operation and maintenance management of three lines: Line-2A, Line-3 and Line-2. Each line is built thanks to ODA from different countries. As a result, the specifications of rolling stock and the operation and maintenance processes as well as the technology used for each line differ. HMC is a new company and does not have experience in operation and maintenance of urban railways. Therefore, they are going to meet the safety and technical requirements at the start of the operation based on the rules, procedures and manuals provided by the contractor. In order to ensure integrated management of maintenance, HMC will establish common maintenance rules including regulations on inspection periods and items. However, they will not describe details of the technical requirements.

However, some time after operations on each line have started, HMC must establish common management rules in order to ensure safe and effective maintenance while taking the following factors into consideration.

- Frequency, cause and prevention measures of failures and accidents.
- Contents and measures of inspection and repair.
- Compatibility of the maintenance process with the current state of Vietnam and of the company.

In the rules, periods, items and methods of inspection may be integrated - as shown below - for every line.

Inspection periods: Appropriate inspection periods to ensure safe operation will be considered and determined. The appropriateness of the periods may be the shortest period among the all lines. However, if failures rarely occur on the line with the shortest period, an average period can be considered.

Inspection items: Inspection items should be integrated. Among the available lists of inspection items, the one with the most detailed contents may be selected.

Inspection method: Among the inspection methods used on each line, those that are most effective and advanced will be employed.

Note: Satisfying all of the above requirements will increase maintenance costs for personnel, equipment and technology etc.

4) Calculation of Number of Maintenance personnel

4.1 Method of Calculating Number of Maintenance Personnel

Several methods are available at present for calculating the number of personnel required.

- Method of calculating number of personnel
- Calculation method based on the workload and work standard
- Calculation method based on work efficiency
- The way of employing a similar method
- Comprehensive method

4.2 Calculation of Number of Necessary Maintenance Personnel Based on Experience at Tokyo Metro

- This manual describes how to calculate the number of personnel who are directly engaged in the maintenance. The calculation method applied here is based on the workload and work standard. The following describes how to apply this calculation method to personnel including a personnel on duty and administrators.

- The maintenance personnel must include personnel who engage in rolling stock maintenance and monthly maintenance at Inspection Yard, and personnel who carry out medium- and large-scale repairs at Workshop.

a) The number of personnel who directly carry out maintenance is calculated as shown below (medium- and large-scale repairs).

Divide the maintenance work into small groups, and set the time required for each task as Tn.

Total time for each task is Tt = Σ Tn (n = 1 to n).

In order to determine Tn, each personnel must report the work to be carried out and the amount of time required to complete it.

Example: When three maintenance personnel are allocated for bogie (P1, P2 and P3)

	T1			T2			T3			T4		
	P1	P2	P3	P1	P2	P3	P1	P2	P3	P1	P2	P3
day1	5	5	5									
day2				5	5	5						
day3				2	5	3	3		2			
day4				2	5	3	3		2			
day5							5	5	5			
day6										5	5	5
day7										5	5	5
total	15			35			25			30		

According to the above formula,

Tt = T1+T2+T3+T4= 105

Total work time per year is: Ty= Tt*Ny+α

Ny: The number of trains maintained per year

α: Backup time for the maintenance. At Tokyo Metro, Backup time = 40% to 50% of Ty time is usually set (Training, cleaning of Workshop, meetings, research, etc.).

Here, the backup time per day is set to 1 to 2 hours/personnel based on the given conditions in Vietnam. In this case, backup time α is 12 to 25% of Ty.

Total working hours of personnel per year:

Pt= 8*(365- d1-d2-d3-d4)

d1: Number of weekends in a year, d2: Annual national holidays, d3: Annual paid holidays, d4: National holidays for various reasons. “8” represents the number of working hours in a day in Vietnam.

Thus, the required number of personnel is:

Pn= Ty/Pt

Upon the opening of Line-2A, Tt cannot be determined based on actual work. Therefore, to calculate Tt of Line-2A, and the number of personnel and time required for maintenance work are compared based on the assumption that the maintenance plan and working items are almost the same in China and Japan.

At Tokyo Metro, Tt is as shown below (When inspecting a 10-car train)

	場所 Place	車両の状態 Condition of rolling stock	検査時間 Inspection time	保守係員数 Number of maintenance staff
列車検査 6-day inspection	検車区 Inspection yard	在姿 On rail	約1時間* About 1H*	2* 2*
状態・機能検査 Inspection of condition and function			約1日(約7時間)* 1D(about 7H)*	10 - 15* 10 -15*
重要部検査 Inspection of important and critical part	工場 Workshop	レール上ではない (多くの装置は車体から取り外される) Out of rail (Many equipment are removed from car body)	約25日* About 25D*	約50* About 50*
全般検査 Overall inspection			約25日* About 25D*	約50* About 50*
臨時検査 Additional inspection	不定 Any place	状況による It depends on the situation	状況による It depends on the situation	状況による It depends on the situation

*保有数が600両程度の箇所で検査が実施される場合の数値である。
The number is for a scale on which 600 cars are inspected.
*この工場では、1編成が10両であり、5両を重要部検査、5両を全般検査の組み合わせで検査を実施する。
In this workshop, train set is 10cars, 5 cars are inspected important and critical part the other 5 cars are inspected overall inspection at the same time.

b) Calculation of the number of personnel who are directly engaged in work (Monthly, daily)

In Tokyo Metro's Inspection Yard, the following personnel are allocated.

a. Administrative personnel (personnel management, preparation of maintenance plan and dealing with failures)
b. Monthly inspection personnel
c. Rolling stock inspection personnel
d. Repair personnel
e. Operation line response personnel (restoration of troubles on operation lines)
f. Other maintenance personnel
g. Drivers at depots
h. Signal control personnel at depot
i. Rolling Stock cleaning personnel
j. Wheel grinding personnel

❖ The number of personnel who are directly engaged in the monthly inspection is calculated as shown below.

Pn= Tt * Nm*(1+β)/8 (Where, Nm: The number of trains to be inspected per day)

Total time required to complete inspection of 1 train set is Tt = Σ Tn (n = 1 to n). “8” represents the number of working hours in a day in Vietnam.

- In order to determine Tn, each personnel must report the work to be carried out and the amount of time required to complete it.
- Nm: The number of train sets to be inspected per day.
- In Japan, β<1 (β: Additional time includes the time for moving from a place to another, waiting time, break time, etc.) As the above α, β should be set appropriately (0.13 to 0.25).

- Upon the opening of Line-2A operation, Tt cannot be determined based on actual work. Therefore, to calculate Tt of Line-2A, the number of personnel and time required to carry out maintenance work are compared based on the assumption that the maintenance plan and working items are almost the same in China and Japan.

❖ Number of personnel for daily inspection

The personnel for 10-day inspections are divided into several groups. Each group, consisting of two personnel, engages in rolling stock inspection. The time required for inspection of 1 train set is 1 to 2 hours.

❖ See Attachment 2 for the estimated number of personnel required for Line-2A.

❖ Duty hours:

- The personnel responsible for technical inspections, medium- and large-scale repairs carry out their assignment during business hours.
- Regarding daily inspection personnel, Shift work system are adopted in order to ensure allocation of daily inspection personnel to carry out inspections and operations at a depot in accordance with the daily train operation plan from 5:00 to 23:00.
- Personnel who engage in daily inspections at the depot are classified into four groups (A, B, C and D). Their shift duty hours are as described below.
- Shift1: 4:00 to 13:00
- Shift2: 12:00 to 21:00
- Shift3: 20:00 to 4:00 the next morning
- Example: Three shifts for a week is prepared for daily inspection, dispatching and driving at the depot.

Group	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
A	Shift 1	Shift 2	Shift 3	Holiday	Shift 1	Shift 2	Shift 3
B	Shift 2	Shift 3	Holiday	Shift 1	Shift 2	Shift 3	Holiday
C	Shift 3	Holiday	Shift 1	Shift 2	Shift 3	Holiday	Shift 1
D	Holiday	Shift 1	Shift 2	Shift 3	Holiday	Shift 1	Shift 2

Daily inspection of Line-2A must be carried out after train operation hours or during a time when the train are not in operation during the day. Therefore, three shifts shall be considered based on the following.

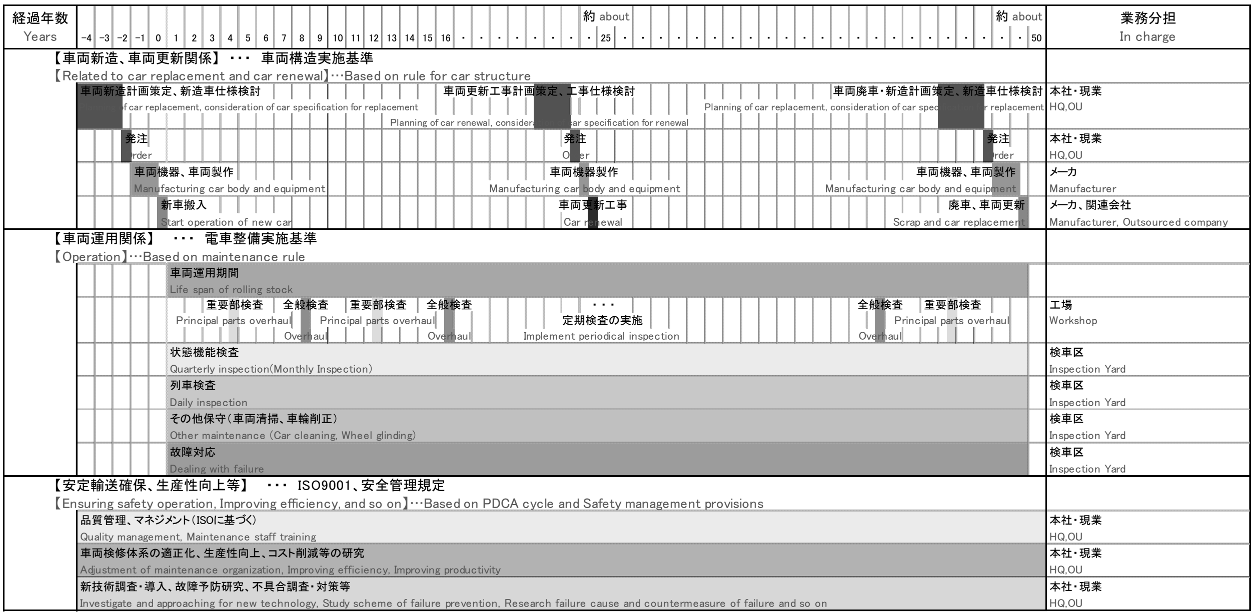
Principles of three shifts

- To observe the labor regulations.
- To satisfy the workload and work requirements.
- To secure the minimum number of personnel necessary.
- To avoid taking over between shifts during busy hours.
- The break time for each shift is 1 hour.

5) Renovation of Rolling Stock and Procurement of New Rolling Stock

5.1 Outline of Service Life of Rolling Stock and Work on Rolling Stock During the Service Life

- Generally speaking, the service life of rolling stock in Japan is about 40 to 50 years. However, according to the specifications of urban lines in Hanoi such as Line-2A and Line-3, the service life of trains in this country is about 30 years,
- In order to meet the requirements for safety, operating capability, passengers' demands and advanced technology during the service life, a rolling stock is generally renovated halfway through its service life (about 20 to 25 years) after its initial use.
- The following shows examples of the work carried out on rolling stock in Japan during their service lives.



5.2 Procurement of New Rolling Stock

❖ Consideration on basic items related to procurement of new rolling stock

- Consideration on procurement of new rolling stock
  - ✓ Replacement with a new rolling stock can save more maintenance cost than renovating it. However, purchasing new rolling stock will cost more than renovating initially. Therefore, it is necessary to consider total costs for life cycle of the rolling stock so as to be most effective to make decision alternatives of procurement of new rolling stock or renovation.
  - ✓ Decision on equipment for new rolling stock or renovation needs to take requirement of long-term use of the equipment into consideration; the equipment must ensure normal operation for durable years. Consideration and diagnostic of degradation level of the equipment in use can be performed by manufacturer before replacing them, if necessary.
- Selection of equipment with modern, advanced standards and high reliable level
  - ✓ Basically, it is required to select modern, advanced equipment with high reliability as equipment shall be used in a long time, thus slow degradation and aging is required in the future. Moreover,

advanced equipment that met requirements can be provided by the contractor as spare equipment if necessary in a long term.

- ✓ Equipment must meet high reliability, efficiency, and durability and test requirements before selection.

- Consideration of technical optimization
  - ✓ It is necessary to consider specifications based on operational requirements and cost of the equipment, ensuring compliance with plans and financial capacity of the company.
  - ✓ Consideration, which is for equipment with advanced technical specifications on new rolling stock and renovation, should be carried out based on a basis of suitability with actual operation, maintenance and management capacity of the company as well as consideration of optimizing number of spare device saving cost.
  - ✓ It is required to consider integrating specifications for new rolling stock and rolling stock renovation in the future.

    Therefore, optimal requirement is made based on the current state of financial capability, planning, operational capacity, maintenance and technical specifications of the equipment.
- Selection of equipment suitable with customer demand
  - ✓ Selection of equipment satisfying customer demand.

❖ Plan of Procurement New Rolling Stock

- Plan of purchasing new rolling stocks is made annually, allocating amount and timing of procurement. Procurement plan must ensure the effectiveness of procurement and consider investment balance of procurement of new one of the years.
- After new rolling stock are introduced, trial run and training must be carried out.
- Purchasing new rolling stock is also considered in some emergency case such as accidents, change of operational plans etc.
- Replacement of signal equipment (new technology) on new rolling stock will be considered in accordance with signal device on track when change is requested.
- Bidding for procurement of new rolling stock
  - ✓ Usually new rolling stock are purchased on the basis of technical specifications, the Company will require manufacturers to offer completely assembled product. However, as some companies that have experience and capabilities in Japan as Tokyo Metro, JR, the Company will place an order to the manufacturers specializing in producing such corresponding carbody, equipment control, brake, bogie. After that these equipment shall be sent to carbody manufacturer to assemble complete rolling stock.
  - ✓ The advantages and disadvantages of placing an order with one contractors for assemble and completion and contractors specializing in producing one device and one company managing completion. It is as follows;

	One manufacturer	Several manufacturers producing different equipment

Advantage	-Management of coordinated interface will be responsible by the main manufacturer. - Cost may be lower. - Suitable with company that does not have much experience as well as maintenance capacity.	- Management of detail and quality of equipment as required. Increase reliability, availability, and safety of the rolling stock. - Convenient in maintenance of each device afterward.
Disadvantage	-Difficult to manage each detail of each equipment as required. - Maintenance process of each equipment afterward shall not have a close contact and assurance of each equipment with manufacturer of that equipment.	- Management of coordinated interface will be responsible by the company, leading to request of a large number of personnel – increase of costs. - High capacity personnel to manage and supervise each equipment.

5.3 Renovation and Remodel of Rolling Stock

- Renovation and/or remodel work of rolling stock is conducted halfway through their respective service lives (about 20 to 25 years after launch although this depends on the technical specifications of the rolling stock in question. In Hanoi City, this work is conducted about 15 years after launch according to the current specifications of urban railway lines in the city.) Large scale renovation in Japan generally requires three months. In such a case, a range or steps are taken to enable equipment to operate up to the limit of their service lives. Basically, when carrying out renovation of rolling stocks some equipment such as body, bogie frame can be retained when these parts are inspected to be requirement ensured.
- Carbody: Mostly replace display panel, internal control, electrical wiring, and electrical insulating materials, sound proof materials etc.
- Equipment: Basically to be considered to replace almost all. Some other equipment after inspection, maintenance and repair in the Workshop are found to ensure operations can be reused. Replacing main motors, control equipment, braking equipment, power supply equipment, ventilation etc.
- The costs of renovation in Japan are about 50% of that required to purchase a new rolling stock.
- Replacement of signalling equipment (new technology) will be considered suitable with signalling device on the track when change is requested.
- Replacement of electric devices should be considered approximately 10 years after launch.

The process of renovation and remodel of rolling stock is complied with Circular 02/2009/TT-TT BGTVT and No.05/VBHN-BGTVT dated 27 Jan 2014 regarding quality control, safety engineering technical and environmental protection.

- Design
- Design evaluation
- Check of manufacturing, installation and completion

- Periodical inspection of vehicles

Concerning the above:

+ Three copies of the design documents prepared by a design company or production company that meet the design requirements in the regulation are submitted to the registration body for verification. The following points are considered for the design documents.

a) Entire drawings before and after the renovation.
b) Technical documents which includes configuration of equipment and systems used for the renovation.
c) Descriptions and calculation sheets regarding details of the renovation.

+ Certification of design

a) Review of the design documents is conducted for the product before production, before first assembly or before the renovation.
b) Certification of design involves collating and checking the product's design documents against existing technical criteria and standards. Certification of design takes place within 15 days of receipt of legitimate design documents. When the certification body extends the certification period due to the necessity of receiving additional documents, the certification body must notify the design company or production company of this fact in writing.

+ Inspection of renovated vehicles by Registration Authority

Technical documents used in the inspection process include the following.

a) Design documents of renovated means that are verified by the registration body.
b) Quality certificate (when quality certificate is necessary for a product) of the system and equipment configuration used for renovation of the vehicles, or technical documents.
c) Production company's documents on the inspection and inspection for acceptance.

Contents of the inspection include inspection of the quality of the renovating vehicles in the context of the existing technical criteria and standard, and review and evaluation of the design documents for renovation that have been verified by the registration body.

Inspection method: Inspection on a vehicle basis

6) Maintenance Budget Calculation Method

- Budget calculation method (11/2012/TT-BXD)

Workload- and unit price-based method: It is based on the unit price of each relevant to the budget prepared for the workload, inspection, maintenance, periodic and additional repair that are implemented according to the maintenance plan.

Ratio-based method: This method applies to calculation of the costs for preparation of the maintenance plan as well as preparation and management of the maintenance documents.

- Basically, the costs involved in maintenance include the following items.

a. Personnel

This cost is not referred to in the maintenance budget calculation since it is calculated as part of the overall costs of the company.

b. Materials and equipment

They refer to every necessary device and supplies. They include the following:

- Devices and equipment for replacement
- Consumable supplies

c. Tools and technical materials

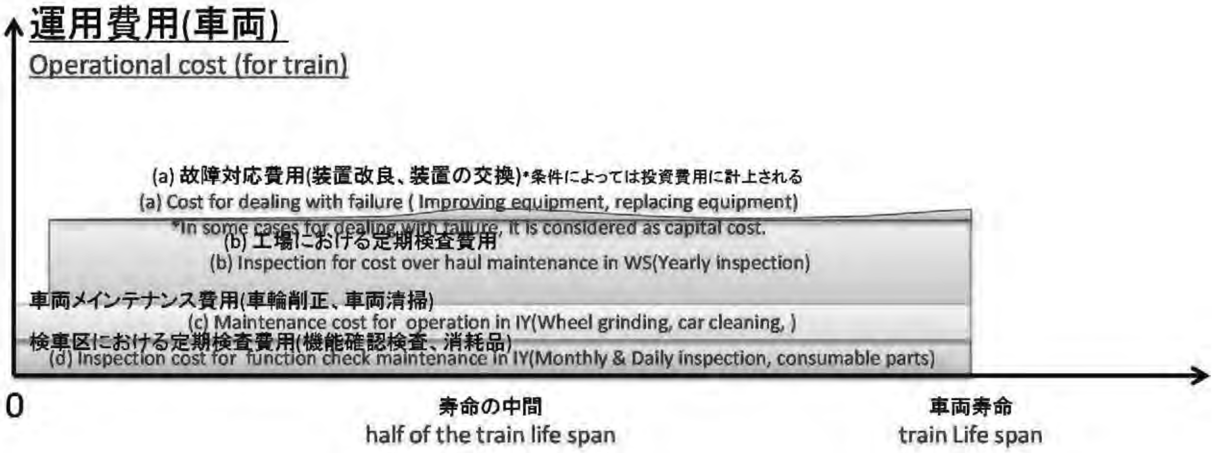
- Replacement of tools
- Purchase of new tools and technical materials
- Lease of devices

d. Outsourcing-related matters

6.1 Overview of Rolling Stock Maintenance Costs

The operational costs are the ones that are incurred during the service life of rolling stock in order to maintain their performance in accordance with the technical requirements, and to help ensure they continue to operate as expected. In the case of an urban railway currently managed by Tokyo Metro, the maintenance costs are as shown below.

❖ Operational cost



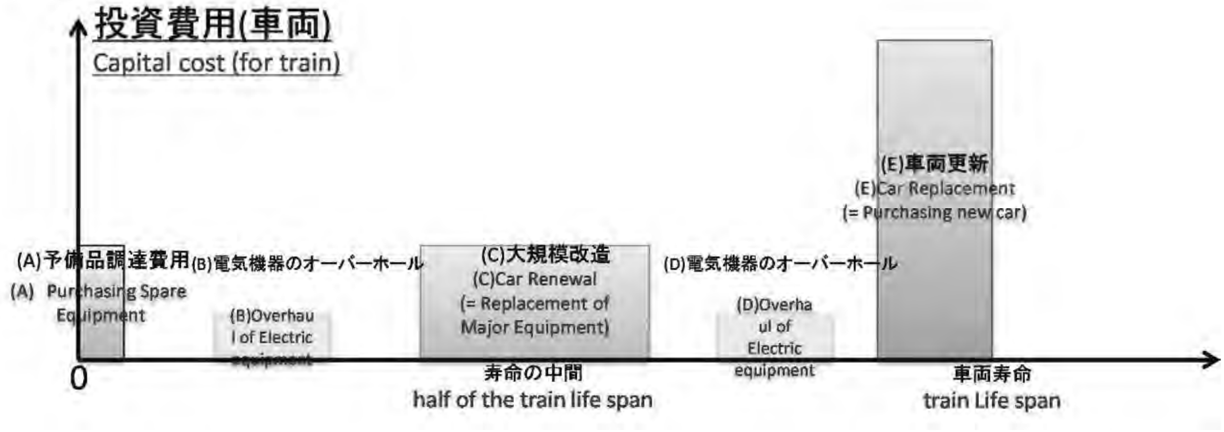
In the above, (b) represents the total costs of replacement devices at the Workshop, and (d) represents the total costs of function inspections, materials and consumable supplies. According to the experience at Tokyo Metro, annual costs of the above items are as described below when the purchase costs of a new 1 train is set as 100%.

b = 10% / year ("b" is the annual cost of Workshop inspection for a 13 train sets, and this cost corresponds to 10% of the purchase cost of a new 1 train.)

a+c+d = 12%/year

(Currently c is outsourced at Tokyo Metro. At HMC, this item will be directly conducted by the company.)

❖ Capital costs (Major items)



(A) in the above belongs to the procurement contract with the suppliers for each line among the new lines in Hanoi.

The following can be stated based on the experience at Tokyo Metro.

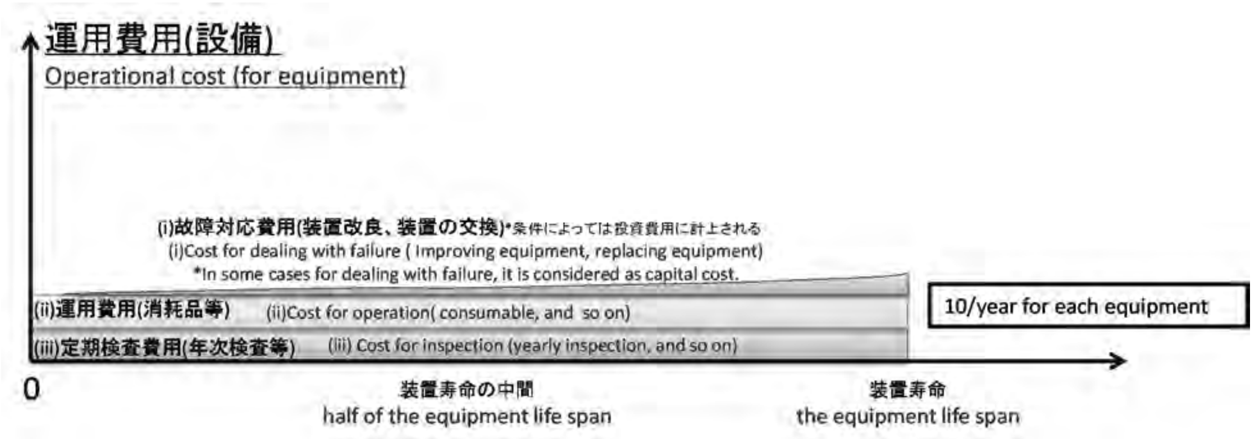
Costs of B and D are approximately 1/4 that of 1 train.

Costs of C are approximately 1/2 that of 1 train.

These costs, however, depend on frequency of failure, maintenance method, company's maintenance policy (preventive maintenance or corrective maintenance), etc.

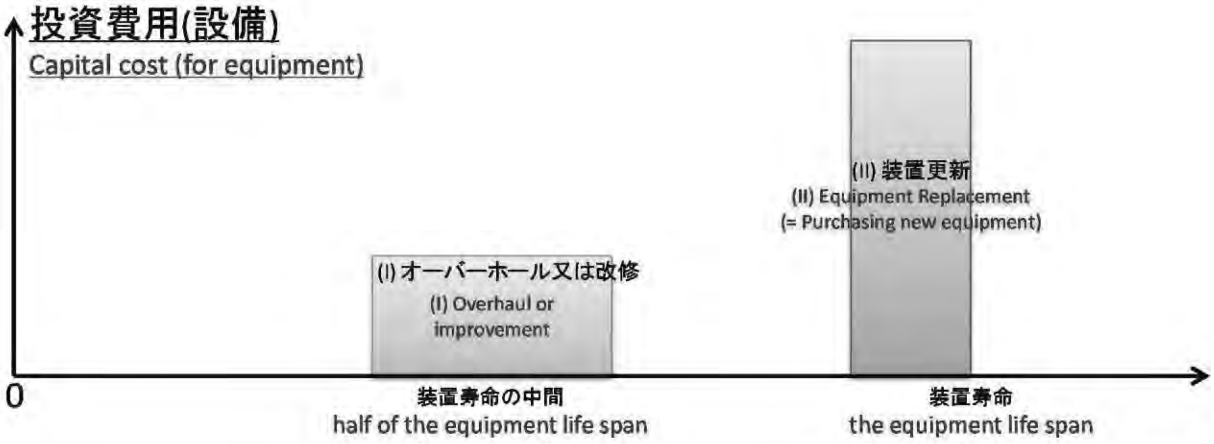
❖ Costs of equipment and devices for maintenance

- Operational cost of equipment: It is the maintenance cost for maintaining the operation of the equipment and devices for maintenance. It includes the following.



In the above, the total cost of (i+ii+iii) items is about 10% of the new purchase cost of the equipment (assumed based on the experience at Tokyo Metro).

- Capital cost



In the above, i is about 1/2 of the new purchase cost (ii) of the equipment (assumed based on the experience at Tokyo Metro).

6.2 Maintenance Budget

a. Periodic inspection

- Replacement devices
- Estimation will be prepared based on the demand for the types and number of devices and equipment to be replaced according to the periodic inspection period, equipment service life, maintenance procedure and manual. The above estimations are summarized. The above includes the number of devices to be replaced according to the annual, monthly and daily inspections. (In the new operating company, demand for the initially replaced devices shall be calculated based on the periodic inspection period, the service life of equipment, case examples of devices in the similar projects and the data provided by contractors.) In the initial phase of operation of Line-2A (for two years from start of the operation), the type of inspection that requires disassembly of the equipment installed on the rolling stock is not basically conducted. Thus, the demand for the devices to be replaced is depend mostly on the monthly and daily periodic inspection. (At this stage, it is not necessary to refer to the devices to be replaced in the medium-scale and large-scale repairs.)
- The unit price of equipment shall be determined based on that issued by the government agency or (when the unit price is not yet issued by the government agency) that issued from the similar project, or that provided by the contractor.
- Number of spare of these equipment and devices
- Consumable supplies and fuel:
- Consumable supplies that are replaced in most of the inspections (brake pads, collector shoes, etc.)
- Oil, lubricant and fuel
- Other materials: Welders and comprehensive electronic devices

Demand for these shall be determined based on the inspection period, frequency of inspection and maintenance during the planned period, condition and operating state of the equipment, and the company's experience gained in the previous term.

A new operating company should estimate the demand for consumable supplies based on the periodic inspection period, maintenance plan, figures and experiences provided by the contractors, and the demand for consumable supplies observed in the similar projects.

- The unit price of equipment shall be determined based on that issued by the government agency or (when the unit price is not yet issued by the government agency) that issued from the similar project, or that provided by the contractor.
- Outsourced inspection items and maintenance: Based on the contract, during the planned period, the payment to be made to the contractor as well as the scheduled workload to be consigned to the contractor and its contract price should be added.
- Number of spare devices and consumable supplies to be prepared for the replacement process.
- Other than the above, circulation spare device should be prepared in order to equalize the workload during the inspection period depending on the actual situation of the company and the maintenance method. This approach is applied to the Workshop. These spare devices will be considered by the company in the next phase, and will be used for periodic inspections and repairs carried out at the Workshop.

b. Other maintenance

- Include the costs for cleaning and wheel grinding.
- Based on the demand for the equipment and consumable supplies that were purchased with the previous budgets, prepare appropriate budgets for the work to be implemented.
- The unit price of equipment shall be determined based on that issued by the government agency or (when the unit price is not yet issued by the government agency) that issued from the similar project, or that provided by the contractor.
- Outsourcing of works relevant to this work must be carried out based on the contract and unit price.
- Additional matters

c. Repair and replacement

• Replacement devices for repairing failures.

- Replacement devices and equipment for failures.
- To do so, it is necessary to estimate the type and quantity of the equipment that will be replaced during the planned period.
- It is necessary to estimate the quantity of devices and equipment to be replaced for dealing with failure.
- Decisions on the demand for devices and equipment during the planned period must be made based on the company's train operation, frequency of failure and demand for replacement in the previous period. (Generally, the last 3 to 10 years are the reference period.)
- According to our experiences in Japan, the devices to be replaced is mainly consumable supplies. (Devices installed on bogie such as valves and bearings, and electric wires and consumable supplies that can not be reused.)

- At a new company, results of the actual operation are not available for estimating the demand for the equipment replacement. Therefore, estimates of the demand for the spare equipment should be made based on the experiences in operation in similar projects, and the contractors' experiences and data reflecting the current status and requirements in Vietnam. For the initial 1 to 2 years, the failures corresponding this item may not occur, and the cost for this item may not be incurred. Since the equipment procurement contract of each line contains the warranty, a failure within the warranty period (Line-2A and Line-3: Two years, Line-2: Five years) will be treated by the contractor.
- The unit price of equipment shall be determined based on that issued by the government agency or (when the unit price is not yet issued by the government agency) that issued from the similar project, or that provided by the contractor.

• Troubleshooting budget: The troubleshooting budget consists of the following two blocks.

- Repair work carried out by the company personnel, such as welding and riveting, will not require a lot of costs basically.
- In the case of a large-scale repair work, the company cannot directly deal with it. Therefore, it is necessary to prepare a budget for outsourcing the troubleshooting. The method of calculating the budget for this item corresponds to that of the additional maintenance cost of the previous year, or it may be determined as a percentage of the prepared budget. Currently in Japan, the method based on the average of the last three years is employed. A new company may choose the cost of this item to be within 10% of the total cost since the company has no experience of the operation or the previous data. 10% is the reserve fund of the construction budget in Vietnam. The size of the budget for this item depends on the frequency of failure, technical specifications of rolling stock, and the company's policy regarding maintenance and train operating methods.
- In an emergency, the troubleshooting cost is reported to HQs of the company for their review.

• Improvement cost of devices and equipment for a failure

- In the process of dealing with failures, the company should understand the necessity that improvement and enhancement of equipment quality is important in order to prevent failures. This kind of budget is reviewed and allocated to each equipment in order to secure the operation plan and safe operation while taking the company's financial standing into consideration.

  In this case, functions and performance to be added are considered based on causes of failures, and the technical specifications and budget of the target equipment of purchase are finalized.

  The budget for equipment replacement for the purpose of improvement is allocated based on the company's operation-related experience in the previous term.
- Practices at Tokyo Metro

  8 to 10 years after launch: Replacement of electronic devices (these devices are improved)

  20 to 25 years after launch: Most the equipment (most of the electronic equipment and electronic devices) are replaced. This cost is included in this kind of budget.

d. Renovation of Rolling Stock and Procurement of New Rolling Stock

• New purchase or additional purchase of rolling stock

- In the planned period, the number of rolling stock to be replaced is considered based on the service life, and the operating period and travel distance of the rolling stock. In many countries, the rolling stock replacement cycle is about 50 years. Therefore, it is not necessary for the company to consider this replacement in the initial phase.
- If it becomes apparent during the planned period that more rolling stock are necessary to meet operational demands, this issue should be considered. (Based on the new rolling stock purchase request by the company)
- The cost shall be determined based on the unit price that issued by the government agency or that issued from the similar project, or that provided by the contractor.

- Renovation and remodel of rolling stock

This cost should include the following matters.

- To confirm the number of train sets and trains to be renovated based on the renovation cycle and operating period.
- Then, confirming the type and the number of equipment, and consumable supplies to be replaced.
- The type and number of equipment are confirmed based on the specifications of the rolling stock and the service life of the equipment to be replaced. At the same time, the planned renovation should be compared with the similar train sets and trains renovated the last time, or should be studied based on the suppliers' experience, or data from the similar project or company.
- The unit price of equipment shall be based on that issued by the government agency or that used in the similar project, or that provided by the contractor.
- As needed, the remodeling work should be outsourced.
- Outsourcing costs for removing the equipment (when needed).
- It is not necessary to remodel rolling stock for HMC for some time after the start of operation (generally speaking, the above remodeling will take place after about 20 year operation.). However, the timing may become earlier in accordance with passengers' needs, addition of new equipment or technical innovation of the equipment.

e. Costs for maintenance facilities and equipment

- Installation of new facilities or equipment

  The quantity of facilities and equipment to be newly purchased or improved is decided during the planned period based on the facilities’ service life and current condition. The above should include the facilities and equipment that are used for the inspection, periodic maintenance, dealing with failure, remodeling of rolling stock, cleaning and wheel grinding.

  The unit price of equipment shall be based on that issued by the government agency or that used in the similar project, or that provided by the contractor.
- Fuel cost and grease consumption cost
- Repair cost (material and outsourcing)

Decide the budget for this work during the planned period based on the facilities and equipment inspection period, or the contract concluded with the contractor.

- Cost for removing unnecessary facilities and equipment, and cost for moving them to another place, when such is necessary.
- Other outsourcing costs, as needed.

f. Maintenance personnel training cost

Maintenance personnel training cost should be prepared based on the training program. This cost should be included as the common expense along with the office management cost, operation cost, etc. The cost must include cost for outsourcing lecturers and device.

7) Training of Rolling Stock Maintenance Personnel

7.1 Principle of Training

- The contents and format of the education must be practical, enhance the quality of leadership, management and operation in the company business, and improve quality of work of the workers who are innovative and developmental.
- The training program should be rational and appropriate in the framework of the company's work plan.
- The company improves the environment to enable the administrators and workers to learn themselves and improve their capabilities so that they are able to implement their assignments effectively using their actual business expertise and high working standards.

7.2 Types of Maintenance Personnel Training

- Training for new personnel at respective sections
    - Training for new employees
    - Training for the personnel who has moved in from other section
- Periodic training:
    - Training for drivers at depots
    - Training for maintenance personnel to enhance their capabilities and skills
    - Training on safety and health
    - Training for an emergency
    - Training for management capabilities
- Supplementary training: It will be conducted when required.
- Other training
    - Attending a lecture held by an external organization

7.3 Training at Site

- Training is implemented on the basis of actual activities on site.

- During implementation of daily work, the head of each section must confirm the capabilities of their personnel and, if judged necessary, the head should plan to provide additional training for such personnel.
- The head of each section is responsible for improving the capabilities of inexperienced personnel, and allocating an experienced personnel to such personnel in order to train and educate them and help them meet the requirement of the assignment. The company introduces the following to promote the training and education.
  - Exhibition of actually failed devices
  - Exhibition of explanations why and how the failure occurred, what countermeasures were taken, and how should we act against a failure.
  - Experience in using tools
  - Experience of getting injury due to wrong use of tool

7.4 Training on Emergency Response

The maintenance personnel must receive training on emergency response.

7.4.1 Contents of training

a. The way of using emergency equipment
b. Training on restoring from an accident in hypothetical situations (training on derailment, failure of wheelset, failure of bogie, recovery of a separated trains)
c. Information reporting training

7.4.2 Requirements of training

d. Training for relevant personnel (every personnel in the Inspection Yard must receive the training)
e. Training on handling emergency machinery and materials, restoring of accidents in hypothetical situations, and making calls and reporting must be conducted annually on a regular basis.
f. Comprehensive training against accidents (handling of the emergency machinery and materials, information communication, restoration work and cooperation with relevant departments) must be conducted once a year.

7.5 Training Period

Form of training: The period of training depends on its purpose and requirements. Head of each section is responsible for considering and preparing the training period and plan appropriately.

Maintenance personnel training period at Tokyo Metro as a reference

- Training at Tokyo Metro's Inspection Yard

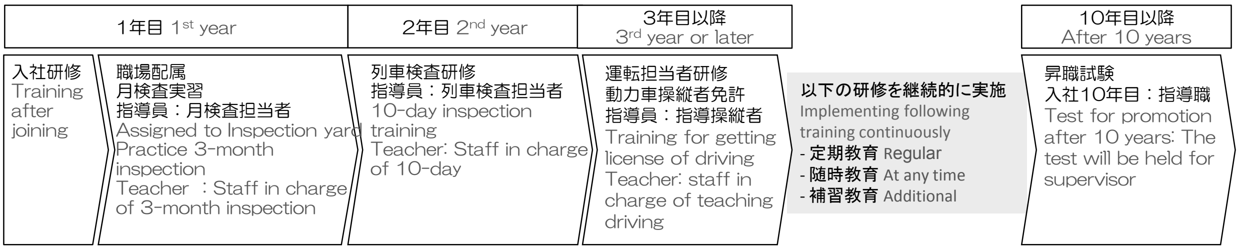
Maintenance personnel is educated so that they can implement every item at the Inspection Yard including the rolling stock inspection and driving train.

Training on theories including confirmation of capability of the personnel: 1 month (25 business days)

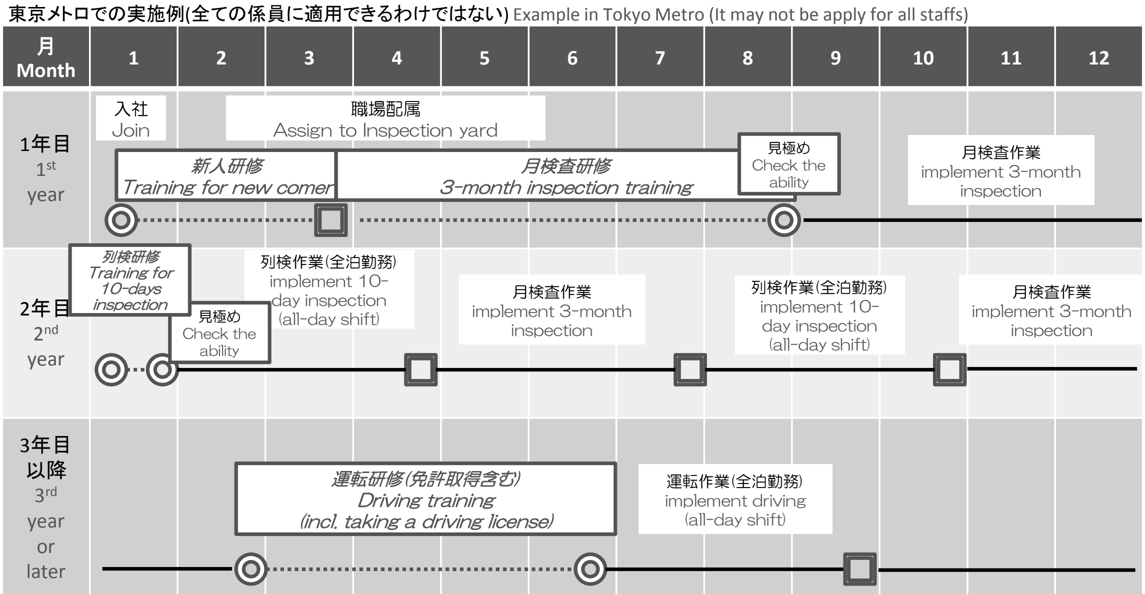
Practical training on 3-month inspection: 6 months to 1 year

Practical training on 10-day inspection, dealing with failure response and repairs: 6 months to 1 year

■検車区係員に対する教育計画(東京メトロの例) The training plan for staff in 'inspection yard'(example in Tokyo Metro)

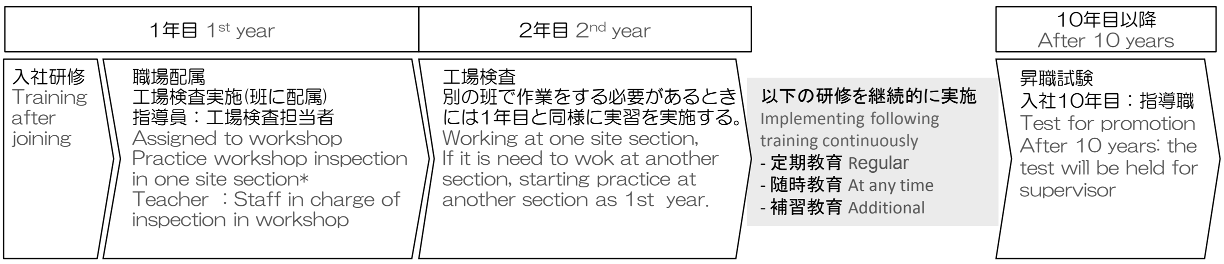


東京メトロでの実施例(全ての係員に適用できるわけではない) Example in Tokyo Metro (It may not be apply for all staffs)



- Training at Tokyo Metro's Workshop

■工場係員に対する教育計画(東京メトロの例) The training plan for staff in 'inspection yard'(example of Tokyo Metro)



*東京メトロの工場では3～4班ある。(制御・ブレーキ、台車、運転整備等)
There are 3-4 site section in Tokyo Metro (such as Controller & Brake equipment, Bogie, General inspection)

Normally, actual training duration for each position is about 1 year. For personnel carrying out the inspection and maintenance, when equipment is disassembled, they will be trained intensively about each of their own in-charge parts.

7.6 Evaluation of Result of Training

When a part or entirety of a training program is finished, it is necessary to evaluate the program to evaluate its degree of attainment.

7.7 Training of Line-2A Maintenance Personnel

Dept.	Staff	Dept., center	Q'ty of staff	Training course (date)

	Categories			**Theory**	**Practice**	**Total**
RS maintenance center, RS department, Safety department	Manager	RS maintenance center	1	25	40	65
	Deputy Manager		2			
	Fixing technique chief		1			
	Fixing technicians		1			
	Fixing technique assistant		1			
	Safety supervisor for technical equipment	Safety dept.	1			
	Management of electricity on the train	RS department	2			
	Management of on-board machines and equipment		2			
	Fixing controlling staff	RS maintenance center	2			
	Management of Train control, inspection		2			
	Senior inspector for electrical equipment on train		2			
	Inspector for electrical equipment on train		4			
	On-board machines senior inspector		2			
	On-board machines inspector		4			
	Management of monthly maintenance and repairs		1			
	Senior staff of monthly electricity maintenance and fixing		1			
	Staff of monthly electricity maintenance and fixing		1			
	Senior staff of monthly machines maintenance and fixing		1			
	Staff of monthly machines maintenance and fixing		1			
	Management of Equipment		1			
	Worker on Equipment type B (wheel lathe)		1			
	Worker on Equipment type C (Train washing machine)		1			
	Supervisor of equipment type B (small train, maintenance car)		1			

Theory: Entire car body, arrangement of electronic equipment, main motor, auxiliary power supply, braking devices, air conditioning devices, bogie, piping, doors, announcement system and display devices.

Practical skill: Work outline, operating procedures, implementation procedures, repair of failure, work flow, job classification and duty assignment.

(For details, see the attached Line-2A Maintenance Staff Training Plan.)

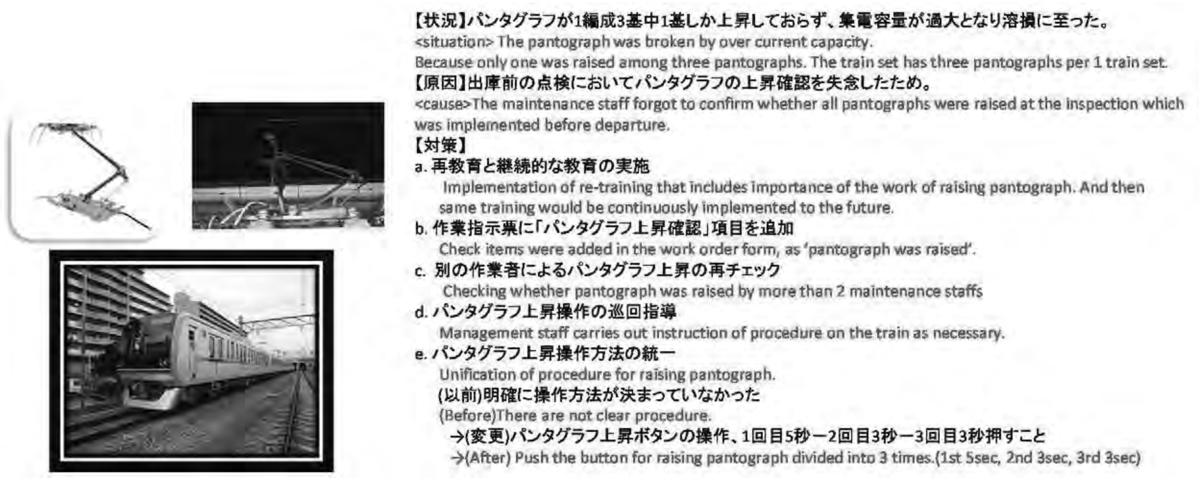
8) Revision and Changes of Rolling Stock Maintenance Rules

8.1 Major Cases that Require Revision and Changes of Maintenance Rules

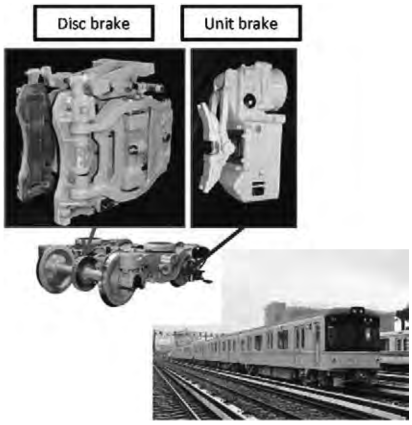
a) When an accident or failure occurred: In order to prevent recurrence of the similar accident or failure, the inspection and maintenance methods must be reviewed again. When implementing inspections or maintenance work, compliance with the rules and manuals must be ensured to prevent the similar accident or failure from recurring. However, an accident or a failure can occur during service operation due to various reasons.

- Therefore, it is indispensable to identify the cause of an accident or failure.
- Thus, reviewing and revising rules and manuals in order to adjust and revise the recovery measures and maintenance method based on the identified causes.
- After revisions or changes are conducted on the rules and manuals, each section must generalize the new rules and train all maintenance personnel based on the new regulations so that they will be able to execute the assignment in accordance with the new rules and manuals.
- An example as a reference: It was unnecessary in the maintenance procedure of a contractor to remove a certain device during the operating period. However, several trouble (ignition, smoke generation, etc.) occurred on the device due to various causes including climate-related conditions. Thus, it became necessary to revise the rules and manuals to conform them to the actual condition. (Such as adding contents of inspection at periodic.)
- Causes of accidents and failures include an error due to maintenance personnel being unsure of the work flow (human error). In such a case, considering and revising the specific work flow were required in order to prevent a recurrence.
- An example as a reference: During train operation, several failures were detected that can affect the safe operation. An investigation into the cause has determined that certain incomplete work flow instructions had been issued to the maintenance worker. Thus, it became necessary to review the rules and manuals in order to determine the necessity of the revision.

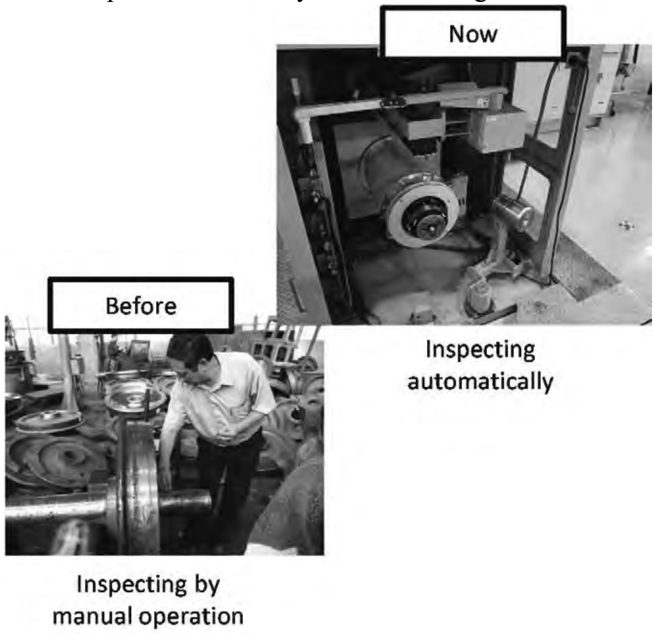
Example:



b) When an equipment on a rolling stock or facility for inspection is changed: It is necessary to revise the rules and manuals in accordance with the change.



An example that a brake system was changed



An example that the working method was changed

c) When organization of the working unit is changed: When improving the work by changing the working method, requirements and workload to the maintenance personnel are changed. Therefore, the number of personnel and organization are changed, too, (increased or decreased). As a result, the rules and manuals related to the personnel arrangement and division of duties must be revised to conform to the new organization system.

8.2 Requirements for Revision and Change in Rules and Manuals

- ✓ Revisions and changes in the rules and manuals must ensure improvement over the existing rules and manuals. The maintenance personnel must accept the revisions and changes, and work in accordance with them.
- ✓ Revisions and changes must be compatible with the existing rules, manuals and other relevant regulations.
- ✓ When a unit proposes revisions or changes, the unit must specifically explain the reasons why and the expected effect.

- ✓ Every revision and change in the rules and manuals must be reported to HQs in order to enable them to consider and grant the necessary approval.
- ✓ HQs shall hold a meeting with relevant departments and contractors to consider the revisions and changes.
- ✓ Every revision and change must be appropriately checked and verified in the consideration. When revising or changing the maintenance rules or manuals, it may be necessary to make certain adjustments with regard to the implementing organization and personnel as well as implementation timing.
- ✓ The related units and sections must explain, within the unit or section, the contents of the revisions and changes specifically to the personnel and train them in accordance with the revisions and changes.

9) Management of Activity of Maintenance Center

9.1 Daily Working Procedure from Start of Day of Duty

+ For the maintenance personnel, supervisors and management personnel who carry out monthly inspections.
  - The supervisor or management personnel have responsibility to call out the names of every personnel before start of work in the day.
  - The supervisor or management personnel assigns work to every maintenance personnel. Only maintenance personnel who meet the health and capacity requirements are allowed to carry out work.
  - All management personnel, supervisors and maintenance personnel get together to do some gymnastics. Precautions or instructions, if any, will be announced there before the work starts.
  - The total time for the above shall be within 30 minutes.
+ For drivers and maintenance personnel for daily inspection and maintenance
  - Before a shift starts, the supervisor or management personnel must call out the names of all maintenance personnel who will work the coming shift.
  - The supervisor or management personnel assigns work for the day. Every maintenance personnel who drives trains in the depot is required to take an alcohol test before starting work.
  - The supervisor or management personnel informs every maintenance personnel about the matters necessary to implement the work, precautions and other information handed over from the personnel of the previous shift.
+ Matters to be handed over and matters to be received between one shift and another
  - Prior to the end of a shift, the supervisor or management personnel of the current shift must hand over the work to the supervisor or management personnel of the next shift.
  - The above personnel in the current shift must convey information about events that occurred, instructions issued and restoration policies taken, if any, in the current shift to the new shift.

9.2 Hand-Over Process

a. Maintenance personnel to hand over the work

The head of each section allocates the shift at Inspection Yard as follows.

Supervisor or Sub Supervisor in charge of the day of duty (daytime inspection shift)

Supervisor or Sub Supervisor in charge of dealing with failures during operation

Place for hand over: Select an appropriate place for hand over in consideration of the work of each section. Normally, the business office under the supervision of the section or Inspection Yard is used so that the work plan and business operations may be carried out smoothly. Hand over during operation time should ideally be carried out at the work place because many trains are operated.

b. Implementation time

15 to 30 minutes though it depends on the details of the matter and type of information to be handed over.

c. Details of matter to be handed over

- Changes in the train allocation and maintenance personnel, failures and other relevant matters occurred during the shift.
- The work plan to be implemented in the next shift such as additional inspection and cleaning.
  The above includes information about a mistake or accident that forces the work plan to be changed. For example, if an accident which suspends train operation occurs, the next shift must review the previously prepared plan, report about the accident to relevant personnel, and make necessary adjustments in consideration of the given situation. For example, when the inspection and restoration of a rolling stock failure have not been completed in the current shift, the current shift must hand over details about the failure and relevant countermeasures to the next shift.
- Change or adjustment of an equipment installed on the rolling stock, disassembly or assembly of an equipment, change due to improvement purposes, etc.
- Other information

9.3 Locations to be managed by Inspection Yard and by Workshop

The boundary between the Inspection Yard and Workshop must be made clear in order to ensure a smooth flow of management tasks, and facilitate clearer responsibility sharing between them when implementing the work. The above includes making it clear in the work where the trains are to be handed over between the two work places.

The trains must be handed over between these work places in accordance with the maintenance plan. Both sides should confirm train hand-over time and notify it each other based on rules. When a scheduled delivery of trains is not possible due to an emergency, the parties should notify each other of it and report relevant information to their senior personnel to review and solve the situation.

9.4 Rolling Stock Inspection before Operation

For the trains that have been parked at the depot, maintenance personnel has responsibility of inspecting it before start of operation. (The inspection should focus on the communication system and lighting.)

For the trains that have been parked at any other location, the driver has responsibility of carrying out the above inspection.

9.5 Driving Train at Depot

Driving train at depot includes the following matters.

- Driving trains from the location where they are parked in the depot to the service line is carried out mainly in the early morning.
- Driving trains from the service line to the parking location in the depot is carried out mainly during the night of the operation day.
- Trains are moved within the depot for the purpose of inspecting the electric equipment and signal equipment, cleaning, wheel grinding, trial run, large-scale Workshop repairs, and maintenance of rolling stock or equipment at the depot.

The following describes the difference in driving between in depot and on service line.

- Generally speaking, CBTC signal is applied on service line, while the depot is not.
- The train operation on service line is managed and controlled by OCC, while the depot is not.

Examples at a depot of Tokyo Metro:

- Outbound and inbound trains at the depot: Weekday: 37 train sets, Holidays: 13 train sets
- Operation within the depot: 10 train sets

Characteristics of driving at depot

- Most of the train driving work are concentrated in a short period in the early morning and nighttime.
- Frequency of driving within the depot is fewer than that for the inbound and outbound.

Types of personnel assignment for driving within depot are as follows;

- Driver who drives train on the service line and in the depot.
- Driver who drives train only in the depot.
- Maintenance personnel who drives train in the depot.

Advantages and disadvantages of driving train at the depot carried out by Operation Department and Maintenance Department

	Driving by Operation Department	**Driving by Maintenance Department**

Advantages	- The time required for the train hand-over process between the Maintenance Department and Operation Department can be reduced. The time required to walk back to the maintenance location after the driving can be reduced. - Train operation as planned is available (risks involving on-time delivery by the other party can be reduced)	- It is easier to prepare and adjust the train allocation plan in order to secure both operation and maintenance work. - The Maintenance Department understands the courses and signals in the depot and, thus the train shunting operations are implemented and necessary instructions can be given more efficiently and easily by this department. In addition, they can efficiently and easily arrange and shunt the trains for maintenance purposes. - This department is more suited to securing safety since they can utilize results of the daily inspection and rolling stock maintenance. (Inspection that is implemented prior to service operation.) - More efficient maintenance is assured. (Maintenance personnel can both drive trains and carry out maintenance.)
Disadvantages	- It is difficult to revise and adjust the train allocation plan when an emergency occurred while operation and maintenance work is being carried out. - It is difficult to move the trains in order to carry out maintenance or issue instructions for that purpose. - Effect of the daily rolling stock inspection before operation is lower. (Inspection carried out by Operation department personnel, not by maintenance personnel). - More drivers who have licenses for the service line will be necessary.	- Hand over time is required, and time for returning to the maintenance location after hand over is also required. - A close confirmation is required so that the trains may be handed over as scheduled.

10) Manual for Dealing with Accident

10.1 Principle for Dealing with Accident

- Secure safety of human and property thoroughly, and make quick and timely responses.
- If an accident occurs, the organizations and individuals who engage in urban railway have responsibility of dealing with an accident together.

- Rescue evacuees immediately, and protect the accident site, national property and evacuees.
- Notify and report an accident to the relevant organizations and individuals timely.
- All organization and individuals who have been informed of the accident must rush to the site of the accident and take appropriate actions.
- Resume train operation on the affected line as soon as possible. Make effort to operate trains as planned. (Depending on the accident situation, ensure smooth train operation by allocating spare trains through consideration.)
- Take measures to prevent recurrence of the accident.

10.2 Requirements

In case of accident – natural disaster, the personnel of rolling stock management maintenance division shall join force with one another and other personnel to take action with the best method to ensure safety of passenger and personnel, paying special attention the following important contents.

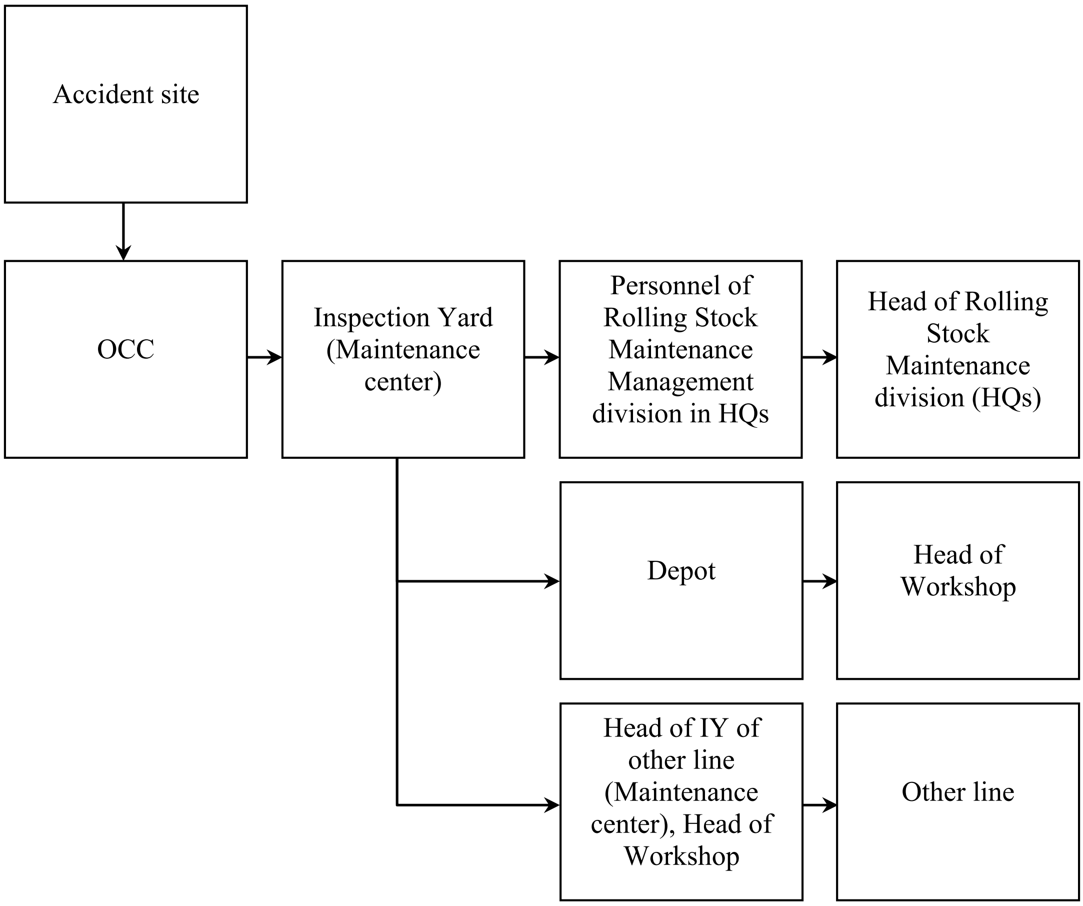
a. To rescue and evacuate the passengers and maintenance personnel.
b. To ensure their own safety and that of other maintenance personnel.
c. To prevent disasters and collateral accidents.
d. To report and inform the accident.
e. To safeguard the property.
f. Other important matters
g. The maintenance personnel must wear gloves when engaging in inspections, rescue and restoration.

10.3 Importance of Initial Action

Head of each section (Head of the Inspection Yard, (Head of Maintenance Center), Head of Workshop, Station Master, etc.) must be aware that speed of the initial action after an accident occurs determines the success or failure of early restoration. Thus, the head of each work place must notify the importance of speed to their maintenance personnel so that no serious problems caused by delays will occur.

10.4 Reporting of Accident

a. When an accident occurred, OU and the Rolling Stock Maintenance Management division in HQs notify and report on the accident according to the following flow.



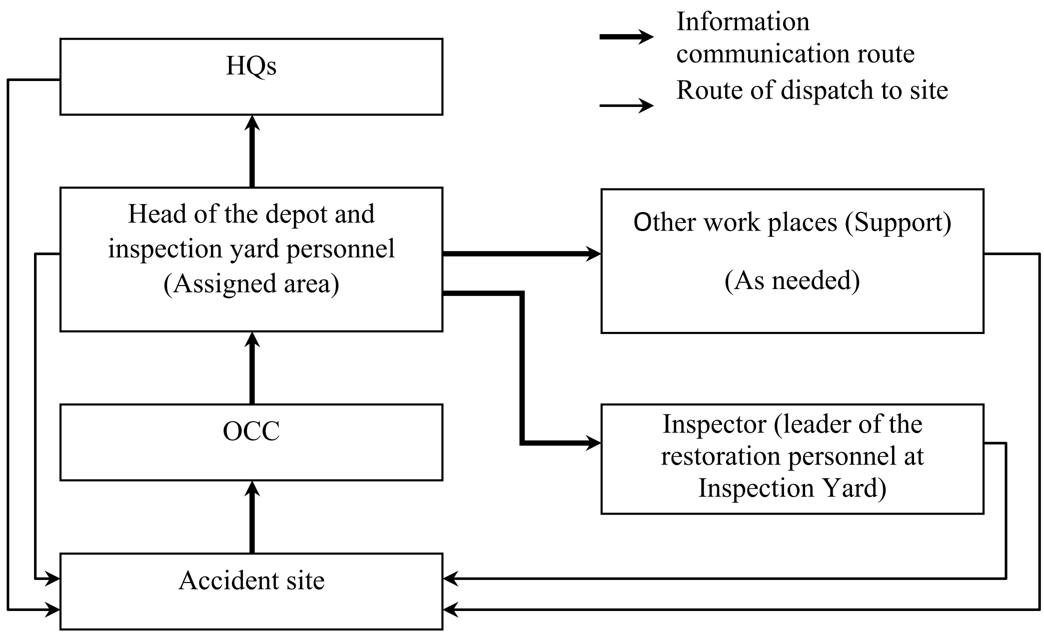
The personnel in charge in each section has responsibility of reporting to each relevant maintenance personnel about the accident, so that restoration work immediately starts.

When a train operation-related accident or disaster occurred in the depot, relevant personnel (driver and maintenance personnel) must immediately report about it to the Head of the Inspection Yard (Head of Maintenance Center) and Head of the depot.

In the above:

- Inspection Yard (Maintenance Center): After being informed of the accident, the personnel who is in charge of dealing with accident must immediately report about it to the Head of the Inspection Yard (Maintenance Center) and relevant personnel of the section.
- The personnel in charge of dealing with accident at HQs (Head of Rolling Stock Maintenance Management division or section personnel): In the case of beginning phase of HMC, this personnel in charge may be the personnel of the Rolling Stock Maintenance Management division in HQs. When the number of lines and rolling stock are increased in the future, a personnel dedicated to dealing with accident will be assigned at the Rolling Stock Department in HQs (it is the same as the current Tokyo Metro).
- When the Accident Response Board is established, the Chief of the Rolling Stock Maintenance Management division shall participate in it according to the regulations. If the section chief is not available, the Rolling Stock Maintenance Management division in HQs shall designate a proxy.

b. Maintenance personnel who is dispatched to the site to deal with an accident



If an accident occurs, the relevant personnel in each section must immediately collect relevant information and dispatch necessary personnel to the accident site as shown in the above figure. When requested to attend the site, the maintenance personnel shall go straight to the site with materials and equipment for first aid and restoration.

10.5 Head of the Depot

- When informed of the accident, the Head of the depot of the line concerned must grasp the situation by immediately dispatching the necessary personnel to the site to collect information, and the Head of the depot must go to the site as quickly as possible. At the same time, the Head of the depot shall, as needed, request the support from another Workshop or work place and make necessary adjustments if they request receiving information or support of Inspection Yard or OCC.
- The Head of the depot and Inspection Yard must be familiar with the lines in their charge on a routine basis so that they can take accurate and appropriate measures for the accident site.

10.6 Role of Maintenance personnel of Inspection Yard -Maintenance Center

When an accident occurs, the personnel on duty who is in charge of accident shall, according to requests received from OCC, rush to the site to collect relevant information, or shall dispatch inspection personnel to the site and have them report on the status of the accident to the Head of the Inspection Yard (Maintenance Center). When support from other Inspection Yard is necessary, the Head of the Inspection Yard (Maintenance Center) or an authorized personnel shall contact the other Inspection Yard or section and arrange dispatch of personnel and equipment to the accident site.

10.6.1.1 When informed of an accident, the supervisor who is in charge of dealing with accident, the Head of the Inspection Yard (Maintenance Center), or the relevant personnel defined in the regulations on duty shall rush to the site with the emergency machinery and materials.

10.6.1.2 The Head of the depot and the Head of the Inspection Yard must prepare necessary emergency machinery and materials beforehand in consideration of the specifications and activities of each line.

10.6.1.3 When informed of an accident or requesting support, every department and personnel shall respond to it as much as practicable, and report the results to the personnel requesting them. At the same time, they must promptly implement the necessary measures such as dispatching personnel, emergency machinery and materials to the accident site.

10.7 Role of Inspector

10.7.1.1 When attending the accident site, the inspector must report on circumstances of the accident briefly and accurately to the accident response personnel on duty. (The inspector is responsible for making a prompt report to the Head of the Inspection Yard (Maintenance Center).

10.7.1.2 The inspector at the accident site must secure the safety of passengers and relevant personnel until the restoration unit arrives and, at the same time, must carry out the necessary emergency measures and restoration works.

10.8 Handling upon Arrival at the Accident Site

10.8.1.1 The Head of the depot, the Head of the Inspection Yard (Maintenance Center) or authorized person must immediately consider, develop and propose a restoration policy based on the circumstances of the accident. The Task Force reviews it and decides the policy.

10.8.1.2 The Head of the Inspection yard (Maintenance Center), the personnel in charge of dealing with accident on duty or an authorized personnel must allocate the personnel and equipment according to the request so that accident restoration can be accomplished in accordance with the restoration policy.

10.9 Configuration of Attending Personnel

The Head of the depot and the Head of the Inspection Yard (Maintenance Center) of each line must decide beforehand the configuration of the personnel who will attend the site to help manage the accident taking into consideration the type of assumed accident (collision, derailment, overturn, fire hazards, etc.) and the specifications of each line. (Inspector, restoration personnel, assistant, informer, etc.)

10.10 Basis of Restoration Work

- The Head of the depot and the Head of the Inspection Yard must decide on the basis of restoration work beforehand in consideration of the specifications of each line and type of assumed accidents. (Derailment, train collision, fire hazards, disaster, etc.)
- The maintenance personnel must be trained and have received instruction in the basis of restoration work so that they understand the necessary accident handling procedures and measures.
- The basis of the restoration work must be implemented in compliance with the safety regulations.

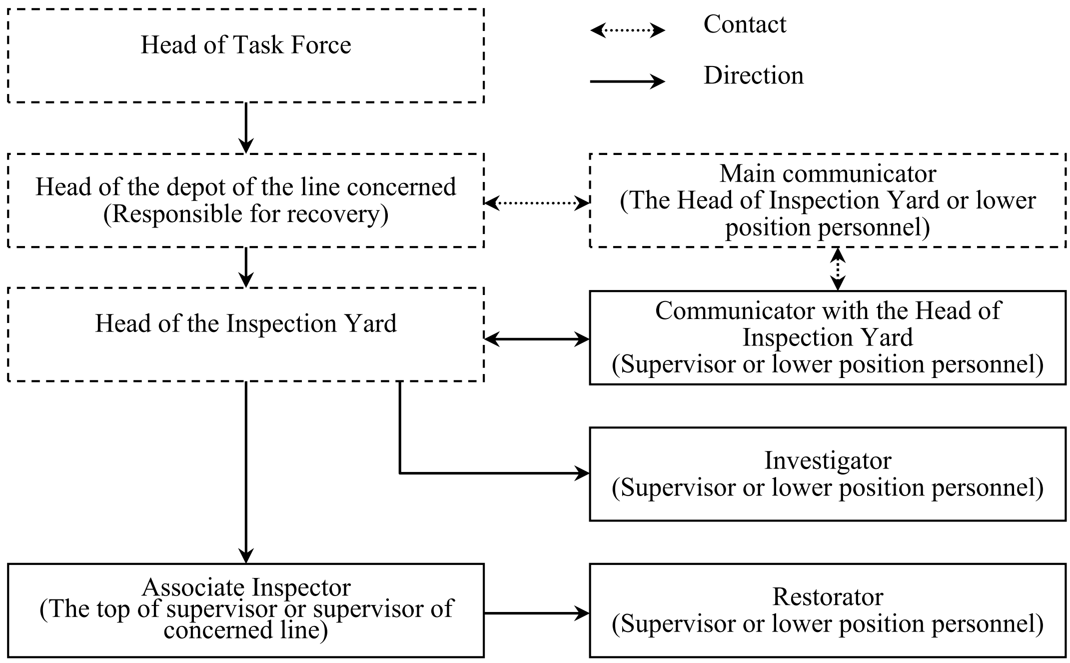
- Training must be carried out for accidents that are anticipated on an urban railway line such as derailment, collision, turnover and fire hazards.

10.11 Work Assignment at Site

10.11.1 Organizations to Implement Restoration Work

- The Task Force is immediately set up to implement restoration.
- The Head of Task Force for accidents that occur due to train operation at the depot or fire hazards shall be the Head of the Inspection Yard (Maintenance Center). (Generally speaking, the personnel in charge of the accident area (Station Master) assumes the position of the Head of Task Force to ensure the safe and immediate start of the restoration work.) When a personnel of the duty position is required, the appropriate personnel shall be designated by HQs or the Accident Handling Committee.
- Other maintenance personnel who are ordered to deal with an accident or disaster must rush to the site in line with the request. List and contact information of the maintenance personnel of the Rolling Stock Department must be indicated clearly so that relevant personnel can contact them when necessary.

  Other maintenance personnel shall act according to the instructions of the Task Force. The organization is composed of the following duty positions with the functions and assignment as described below.



10.11.2 Responsibility of Each Personnel in Charge

Each department shall allocate personnel appropriately depending on the circumstances of the accident.

- Head of the depot

  The Head of depot shall advise the Taskforce to define restoration policy, instruct the Head of Inspection Yard and related personnel to implement and manage restoration activities.

- Main communicator

This personnel assists the Head of the depot and the Task Force, and acts as mediator between the Task Force and personnel who are not at the site.

The personnel is responsible for communicating necessary information to the relevant departments and, as needed, requests their support.

- Head of the Inspection Yard (Maintenance Center)

The personnel is responsible for organizing the restoration work according to the agreed upon restoration policy.

- Communicator with the Head of Inspection Yard

The personnel assists the Head of the Inspection Yard (Maintenance Center) and acts as mediator between the Head of the Inspection Yard (Maintenance Center), restoration personnel and the Task Force. The personnel is responsible for accurately informing the restoration policy-based instructions of the Head of the Inspection Yard (Maintenance Center) and, at the same time, reporting relevant details about the restoration site to the Head of the Inspection Yard (Maintenance Center).

- Associate Inspector

The personnel assists the Head of the Inspection Yard (Maintenance Center) in direction of restoration and implementation of restoration. Generally, the supervisor on duty in the Inspection Yard who is responsible for accidents becomes in charge.

- Investigator

The personnel investigates the circumstances of the accident, and retains records and evident of the accident.

- Restorator

The personnel is in charge of restoring work at the accident site.

10.12 Emergency Machinery and Materials

- The emergency machinery and materials used for dealing with an accident are usually deployed in the Inspection Yard.
- Based on the characteristics of each line (derailment, collision, turnover, fire hazards, etc.), respective OU must create a list of emergency machinery and materials necessary for each type of accident, and sort and prepare the equipment beforehand.
- The emergency machinery and materials must be periodically inspected, maintained and kept in good operating condition. Maintenance records of the equipment, machinery and materials must be created.

10.13 Restoration Training

The Head of the Inspection Yard (Maintenance Center) must implement restoration training in order to enhance the skills of personnel and give them an experience of accident-related restoration work in preparation for an accident.

Contents of training

- Information reporting training
- The way of carrying and handling the emergency machinery and materials

- Training of accident restoration work in hypothetical situations (training on derailment, failure of wheelset, bogie failure, restoration of a separated train)
- Comprehensive training against accidents (handling of the emergency equipment, information communication, restoration work and cooperation with relevant sections) must be conducted once a year.

10.14 Training Plan and Record

10.14.1 The plan and record must be in compliance with the company's training regulations.

10.14.2 Training must be implemented, recorded and stored according to the decided plan.

10.15 Emergency Automobile

10.15.1 Emergency automobile should be maintained according to the regulations and kept in good condition so that they can be used at any time.

10.15.2 The drivers of the emergency automobile should be designated beforehand.

10.16 Route

10.16.1 The Head of the Inspection Yard (Maintenance Center) must check routes in the area that can be driven by emergency automobile for restoration or support purposes. The head should hold a training for concerned personnel to grasp the route.

10.16.2 Head of the Inspection Yard (Maintenance Center) must provide necessary training to the drivers of emergency automobiles so that the specified requirements may be met at an accident.

10.17 Restoration of Rolling Stock Failure after Returning to Depot

i. Investigate the failure after observing relevant circumstance.

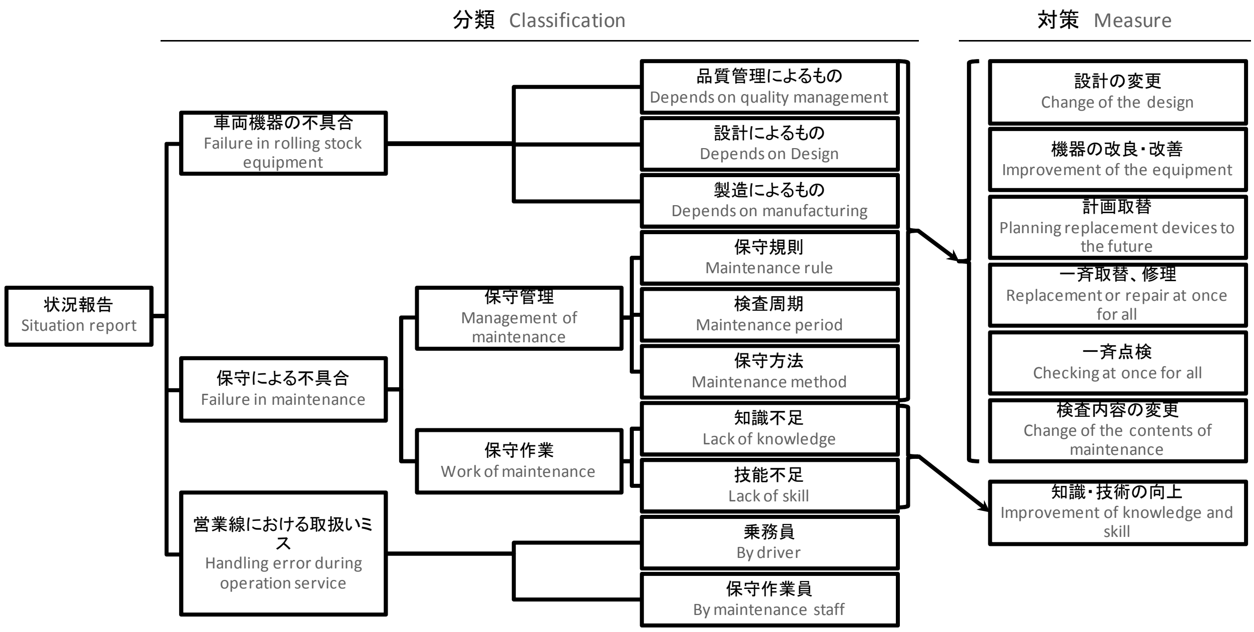
- ✓ Analyze the cause of failure and make a proposal on the restoration measures. Analysis and inspection of a railway accident must be carried out in accordance with the existing regulations.
- ✓ For future reference: In the initial stage, HMC does not have experience in dealing with failure and restoration work. Therefore, the participants, who investigates cause of failure and deals with failure, are not only each division in the company but also the contractor which provided equipment and the concerned organizations. OU is in charge of carrying out investigation and restoration of failure. HQs supports investigation and restoration of failure through adjustments made with the contractor.
- ✓ Although OU is in charge of dealing with failure, HQs is responsible for requesting technical support from the contractor and other relevant external organizations as needed.
- ✓ When investigating a failure, including investigating the cause of the equipment's previous failure and collecting failure-related information from maintenance records and materials, company employees themselves must play leading roles for them.
- ✓ As needed, they will collaborate with the manufacturer in order to conduct a more detailed investigation.
- ✓ The investigation shall be continued until the cause is accurately identified.

- ✓ If the cause is not able to be identified, it is permissible to use the same or spare devices after it has been confirmed as safe.

ii. Take Measures against the Cause of Failure

Based on condition and failure cause, maintenance personnel in charge must promptly carry out restoration or must report to senior personnel in order to restore failure quickly. It is required to check the same failure or the risk of failure on the rolling stock in other sections.

Several types of failure, and countermeasures:



iii. Preparation of Materials (Records of dealing with failure)

- ✓ Records of all failures shall be prepared. These records will become a foundation which can be used for analysis, cause investigation and development of restoration measures. Summarized results, which are accumulated of dealing with failure, can help managers in each division to ensure safety.
- ✓ The section in charge of investigation and restoration of failure, is responsible for preparing a detailed record of circumstances and causes of failures, and relevant countermeasures.
- ✓ The section in charge of investigation, as well as OU and the Rolling Stock Maintenance Management division in HQs, are responsible for storing records on failures.

iv. Reporting to HQs on Failures and Proposals and Recommendations from OU

- ✓ The section in charge of investigation and restoration must prepare detailed records on causes and countermeasures, and report it to HQs.
- ✓ In all cases, OU must report to HQs on circumstances of failure, including train delay time (if any).

v. Sharing information of cause and countermeasure to concerned organizations

The materials that explain the circumstances, causes of failures and countermeasures shall be shared with and notice to relevant employees in order to prevent recurrences of similar failures.

vi. General Handling and Meeting System

- ✓ Information on failures and accidents must be stored and statistically processed periodically (quarterly and annually). Each OU must grasp circumstance of the failures. Each OU must predict failure-related trends by statistically processing and analyzing the data. OU must develop restoration measures based on information and materials on actual conditions of lines, and present it to HQs. Based on the countermeasures for failure, and on the statistical processing and investigation on the failure-related trends, OU shall develop measures that prevent the trends, and propose the measures.

- ✓ HQs and personnel in each concerned OU shall hold meetings periodically every month in order to report and discuss failures and other matters that happened during the month. Another meeting may be held at the end of the month in order to receive reports on various subjects from each unit, including causes of train delays, recently detected failures, and accidents that resulted from mistakes made by maintenance personnel. The meeting will study measures to preventing recurrence of such troubles. Members attendees will be personnel of the Rolling Stock Department in HQs and management personnel of each OU.
- ✓ If a large failure occurs that requires urgent measures, an emergency meeting will be held.
- ✓ If necessary, the company shall consider changing, adjusting the contents and methods of maintenance, repair, or replacement, improvements and equipment throughout the company to prevent recurrence of failure. In such a case, each OU requests HQs to allocate a budget for repairs and/or implementation of improvement measures. Depending on the seriousness of the given failure, it is necessary to consider which is more appropriate - making a company-wide urgent response, or preparing a countermeasure plan.

10.18 Restoration of Failure in the Process of Inspection and Maintenance (Periodic Inspection)

- If an error or failure is detected in the inspection or maintenance processes, the personnel in direct charge of inspection or maintenance should restore the trouble as soon as possible. If the personnel is not able to identify the cause or countermeasures, they must immediately report it to the senior personnel. The detected failure shall be handled as follows:

1. Tentative Measures:
   - ✓ Reinforcing inspections.
   - ✓ Enhancing maintenance quality.
   - ✓ Replacing devices of failed equipment, or entire equipment.
2. After the Cause is identified:
   - ✓ Improving the equipment with design changes and other methods.
   - ✓ Replacing the equipment or its devices.
   - ✓ As needed, revising the inspection method and period.

11) Procedure of Periodic Maintenance

The maintenance procedure shall include the following.

- Preparation and approval of the rolling stock maintenance procedure.
- Preparation of maintenance plan and budget.
- Approval of maintenance plan and budget.

- Implementation of maintenance.
- Preparation of records of maintenance.
- Reporting on completion of maintenance.

11.1 Preparation and Approval of Rolling Stock Maintenance Procedure (See law No.114/2004 Maintenance Procedure in Civil Engineering Work)

- Equipment supplying contractors are responsible for preparing and handing-over the maintenance procedures for rolling stock equipment.
- Basis for preparing rolling stock maintenance procedures:
  a) Applicable standards, regulations.
  b) Similar maintenance procedures if any.
  c) Instructions of equipment manufacturers.
  d) Respective suitable natural conditions.
  e) Related regulations of government's competent authorities.
- Rolling stock maintenance procedures shall be prepared in order to ensure overall covering for rolling stock devices, as the following:
  a) Regulations on technical, technology specifications.
  b) Regulations on objects, methods and frequency of inspection.
  c) Regulations on contents and instructions of maintenance implementation.
  d) Regulations on timing and instruction of periodical replacement.
  e) Instructions of repairing methods for failures; regulations on conditions to ensure labor safety and environmental hygiene during implementation of maintenance;
  f) Other instructions relating to the maintenance.
- Approval

  OU submits the maintenance procedure to HQs for evaluating and approving

  Evaluating of procedures: Rolling Stock Department in HQs

  Approve: General Director

11.2 Preparation of Maintenance Plan

- OU is responsible for preparing rolling stock annual, monthly, daily maintenance plans for respective lines, in order to guarantee safe and effective operation and maintenance plans. Based on maintenance plan, OU shall prepare annual specific cost estimate to submit HQs for assessment, decision making for conducting next steps.
- Contents of annual rolling stock maintenance plan shall include sufficient items as followings: contents of maintenance work and main items, unit, maintenance implementing duration, implementing methods, priority level, quantity/amount of workload and cost estimate;
- Inputs for preparing maintenance plan will include the following:
  - Rolling stock maintenance procedures following the standards in design of OU
  - Train operation plan of OU
  - Human resource plan of maintenance division in OU
  - Failures, problems occurred during operation

- Safety policy
- Training, education plan

- Inputs for calculating annual cost estimate:

  Forecast of the maintenance cost is obtained from the workload finalized in the maintenance plan to follow and the unit price of the maintenance to be implemented for the workload.
  - Annual maintenance plan
  - Estimate of unit price, quantity, devices and equipment
  - Backup plan
- Maintenance plan can be amended, supplemented during the implementation. General Director of the Company or authorized personnel can make decision on amendment, supplement of maintenance plan.

11.3 Approval of Maintenance Plan and Maintenance Budget

Approval of the rolling stock maintenance plan is classified as described below:

- HQs approves the annual rolling stock maintenance plan and the annual budget of OU.

+) Maintenance plan
  - Assessment: The Rolling Stock Department is responsible for evaluating the annual maintenance plan of OU.
  - Approval: Company's General Director

+) Annual maintenance budget
  - Assessment: The Rolling Stock Department evaluates the budget items in collaboration with the Financial Department, and then hands them over to the Financial Department for a final evaluation.

The following are included in the evaluation:

a) Check the compliance between major amount/quantity in the cost estimation with implementing amount.

b) Check the reasonability of application of unit price using for rolling stock, rate of expenses, cost estimation for consulting services and cost estimation for other expenses in maintenance.

c) Defining value of maintenance cost estimation.

- Approval: Company's General Director

- Based on approved annual maintenance plan, OU shall develop detailed maintenance plan for the real date and month of implementation.

11.4 Implementation of Maintenance

- OU organizes the implementation of the inspection, maintenance and repairing of rolling stock in accordance with procedures and maintenance plan if they have sufficient capability. If not, OU studies and proposes to hire capable organizations to implement.
- Maintenance works shall be specifically regulated by steps towards respective related devices in rolling stock.

- Inputs for implementing rolling stock maintenance:
  - Annual, monthly and daily maintenance plan
  - The approved rolling stock maintenance procedure

11.5 Maintenance Records

- The implementation, inspection results, maintenance and repairing works for rolling stock must be recorded and archived for management and tracking.
- Individuals directly implementing maintenance works, technical management, as well as individuals and organizations relating to inspection works, repairing and maintenance works are responsible for taking records.
- Input
  - Implementation of works
  - Inspection result

11.6 Maintenance Completion Report

- OU must report on rolling stock maintenance work annually or when incidents possible to cause disasters may occur.
- OU is responsible for reporting to HQs on results of inspection, maintenance and repairing works for rolling stock after medium-scale repair (4 years), large-scale repair (8 years) and un-scheduled repairs.

12) Implementing Organization

a. Rolling Stock Maintenance Management division in HQs

- This division gives advice to and evaluate the rolling stock maintenance plan and the accident response plan in compliance with the national and company regulations.
- This division inspects and audits execution of the approved maintenance plan by each unit.
- This section prepares the rolling stock maintenance work procedure and the manual for each unit.

b. Maintenance Implement division (Maintenance Center)

- Preparation of rolling stock maintenance plan.
- Implementation of maintenance based on the approved plan.
- Finalizing regulations. This division reviews the work of the implementing organizations in order to give guidance to them.

13) Forms

a. Form of train allocation plan

Long term Inspection & Improvement plan for Workshop Inspection <Workshop>

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Workshop Inspection																																																
Improvement																																																

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Workshop Inspection																																																
Improvement																																																

Yearly Inspection plan for Workshop inspection <Workshop>
Year: 2015

month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Workshop Inspection												
Improvement												

Yearly&Monthly Inspection plan for Monthly inspection <Inspection Yard>
Year:
2015

Month	Jan																													
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Yearly&Monthly Inspection plan for Daily inspection <Inspection Yard>
Year:
2015

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Head of IY check																															

Month	Nov																													
Day	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	
Day of week	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	
Train No. 01																															
Train No. 02																															
Train No. 03																															
Train No. 04																															
Train No. 05																															
Train No. 06																															
Train No. 07																															
Train No. 08																															
Train No. 09																															
Train No. 10																															
Train No. 11																															
Supervisor check																															
Other check																															
Head of IY check																															

Month	Dec																													
Day	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Day of week	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu
Train No. 01																															
Train No. 02																															
Train No. 03																															
Train No. 04																															
Train No. 05																															
Train No. 06																															
Train No. 07																															
Train No. 08																															
Train No. 09																															
Train No. 10																															
Train No. 11																															
Supervisor check																															
Other check																															
Head of IY check																															

Daily operation plan <Inspection Yard → OCC, Operation Dept.>

Date	02/May
Day of the week	Mon

operation No.	train No.
01	
02	
03	
04	
05	
06	
07	
08	
09	
Spare	

under maintenance	train No.
8-years	
4-years	
3-months	
6-days	
cleaning	
wheel grinding	

Appendix8-6-6-1-B

Form of Daily Inspection<Inspection Yard>

Date	02/May
Day of the week	Mon

In charge	Work Shift	A	B
	1st		
	2nd		
	3rd		

Daily inspection	Limit value	Thickness	Stroke	Thickness	Disconnection of mesh wire	Size of wheel flat	In charge	Remark	Required time
		more than 5mm	(120mm)	more than 17mm	less than 30%	less than 50mm at 2part, or less than 75mm at 1part			
	Inspection method	Limit check	(Seeing)	Limit check	Seeing	Seeing			
	Train No.	Current collecter	Brake cylinder	Brake Pad	Mesh wire	Tread of wheel			

Other maintenance (repladement of consumable parts, repair)	Train No.	Situation	Cause and treatment	In charge	Remark	Required time

Form of Monthly Inspection<Inspection Yard>

Date	02/May
Day of the week	Mon
Train No.	

Code No. Inspection	

In charge			

Compressor
1st car

Inspection item	Reauired time to sotore compressed air	Safety valve function	Pressure regulator(turn on)	Pressure regulator(turn off)
Limit value	less tha 4 minutes	880kpa(+0,−20)	640kpa(+20,−0)	780kpa(+20,−0)
Measured value				

Brake test
1st car

Load condition	Empty				Full			
Brake position	Neutral	4th steps	7th steps	Emergency	4th steps	7th steps	Emergency	Safety Brake
Command voltage(standard)	1.47V (+0.15,−0.15)	3.07V (+0.15,−0.15)	3.71V (+0.15,−0.15)		3.70V (+0.15,−0.15)	4.73V (+0.15,−0.15)		
Measured value								
Brake cylinder pressure(sandard)	0kpa (+20,−20)	155kpa (+20,−20)	250kpa (+20,−20)	315kpa (+20,−20)	250kpa (+20,−20)	395kpa (+20,−20)	500kpa (+20,−20)	315kpa (+10,−10)
Measured value								

b. Form of maintenance personnel allocation

Daily staff assign <Inspection Yard>

Date
Day of the week

Day-time shift

Position	Staff Name	Today's assignment
Head of IY		
Supervisor		
Sub Supervisor		
Staff		

<Monthly Inspection>
Car No.
Total Responsible staff

Current collector/ Electric equipment	Today's sork	Responsible staff	A	B	C	D
	Staff name					
Brake equipment/ Motor and compressor	Today's sork	Responsible staff	E	F	G	
	Staff name					
Air brake equipment/ Bogie	Today's sork	Responsible staff	H	I	J	
	Staff name					
Door / Car body	Today's sork	Responsible staff	K	L	M	N
	Staff name					

<other maintenance>

	Staff name
Responsible staff	
Staff	

Work contents	In charge

All-day shift

Group A	Position	Staff name	Today's assignment
Responsible for the day	Supervisor		
Driving and daily inspection	Sub Supervisor		
Dealing with failure during operation	Sub Supervisor		
Driving	Staff		
	Staff		
	Staff		
	Staff		
Daily&other maintenance	staff		
	staff		
Group B	**Position**	**Staff name**	**Today's assignment**
Responsible for the day	Supervisor		
Driving and daily inspection	Sub Supervisor		
Dealing with failure during operation	Sub Supervisor		
Driving	Staff		
	Staff		
	Staff		
	Staff		
Daily&other maintenance	staff		
	staff		
Group C	**Position**	**Staff name**	**Today's assignment**
Responsible for the day	Supervisor		
Driving and daily inspection	Sub Supervisor		
Dealing with failure during operation	Sub Supervisor		
Driving	Staff		
	Staff		
	Staff		
	Staff		
Daily&other maintenance	staff		
	staff		
Group D	**Position**	**Staff name**	**Today's assignment**
Responsible for the day	Supervisor		
Driving and daily inspection	Sub Supervisor		
Dealing with failure during operation	Sub Supervisor		
Driving	Staff		
	Staff		
	Staff		
	Staff		
Daily&other maintenance	staff		
	staff		

Other remarks

Daily operation plan for driving〈Inspection Yard〉

Date	02/May
Day of the week	Mon

In charge	Supervisor	A	B	C	D	E

No.	Dept./Arr.	Dept. track No.	Car No.	Operation No.	Starting time	Arr. track No.	In charge

c. Form of budget preparation

Year/	2015
Line name/	Line-2A
Work Place name/	(Inspection Yard)

Budget contents for 'regular maintenance'<for 1 year>
(OPEX: every periodical inspection)

Item of expense	Type of inspection	Number of cars/fascilities to be	Total amount price	Contents				
				Category	Name of parts	Quantity	Unit price	Sub total
Material cost for inspection & maintenance(Rolling stock)	Monthly inspection							
	Daily inspection							
	Other maintenance							
	Total							
Outsource cost for inspection & maintenance(Roling stock)	inspection(incl.repair)							
	Other maintenance							
	Total							
Material cost for inspection & maintenance(Fascilities)								
Outsource cost for inspection & maintenance(Fascilities)								

Year/	2015
Line name/	Line-2A
Work Place name/	(Workshop)

Budget contents for 'regular maintenance'<for 1 year>
(OPEX: every periodical inspection)

Item of expense	Type of inspection	Number of cars/fascilities to be	Total amount price	Contents				
				Category	Name of parts	Quantity	Unit price	Sub total
Material cost for inspection & maintenance(Rolling stock)	Overhaul							
	Important and critical part							
	Other maintenance							
	Total							
Outsource cost for inspection & maintenance(Roling stock)	inspection(incl.repair)							
	Other maintenance							
	Total							
Material cost for inspection & maintenance(Fascilities)								
Outsource cost for inspection & maintenance(Fascilities)								

Year／	2015-2020
Line name／	Line-2A
Work Place name／	

Budget contents for 'rolling stock maintenance'<mid term>
(OPEX: not every periodical inspection)

No.	Plan name	Period of replacement	Number of target	Number of already finishe	Item of expence	Distinction of expence	2015		2016		2017		2018		2019		2020		Start year	End year	Remark
							Quantity	Price	Quantity	Price	Quantity	Price	Quantity	Price	Quantity	Price	Quantity	Price			
					OPEX	Materials															
					OPEX	Materials															
					OPEX	Materials															
					OPEX	Materials															
					OPEX	Materials															
					OPEX	Materials															
					OPEX	Materials															
					OPEX	Materials															
Total																					

Year/	2015–2020
Line name/	Line–2A

Budget contents for 'rolling stock maintenance'<mid term>
(OPEX: not every periodical inspection)

No.	Name	Distinction of expence	Work Place name	2015	2016	2017	2018	2019	2020	Remark
				Price	Price	Price	Price	Price	Price	
	Rolling stock Regular Maintenance (every periodical inspection)	Materials	Inspection Yard							
	Rolling stock Regular Maintenance (every periodical inspection)	Outsource	Inspection Yard							
	Rolling stock Regular Maintenance (every periodical inspection)	Materials	Workshop							
	Rolling stock Regular Maintenance (every periodical inspection)	Outsource	Workshop							
	Rolling stock Regular Maintenance (not–every periodical inspection)	Materials	Workshop							
	Facilities Regular Maintenance	Materials	Inspection Yard							
	Facilities Regular Maintenance	Outsource	Inspection Yard							
	Facilities Regular Maintenance	Materials	Workshop							
	Facilities Regular Maintenance	Outsource	Workshop							
Total										

Budget contents for 'rolling stock maintenance'<mid term>
(CAPEX: New car&mprovement , cost of wire-off: removal)

Year/ 2015-2020
Line name/ Line-2A
Work Place name/

No.	Plan name	contents	Number of target [unit]	Number of already finishe	Item of expence	Distinction of expence	2015		2016		2017		2018		2019		2020		Start year	End year	Remark
							Quantity	Price	Quantity	Price	Quantity	Price	Quantity	Price	Quantity	Price	Quantity	Price			
					CAPEX	Materials															
						Outsource															
						total															
					Wire-off	Outsource															
					CAPEX	Materials															
						Outsource															
						total															
					Wire-off	Outsource															
					CAPEX	Materials															
						Outsource															
						total															
					Wire-off	Outsource															
					CAPEX	Materials															
						Outsource															
						total															
					Wire-off	Outsource															
					CAPEX	Materials															
						Outsource															
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					Wire-off	Outsource															
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					CAPEX	Materials															
						Outsource															
						total															
					Wire-off	Outsource															
					CAPEX	Materials															
						Outsource															
						total															
					Wire-off	Outsource															
Total					CAPEX	Materials															
						Outsource															
						total															
					Wire-off	Outsource															

	Year/ 2015-2020
	Line name/ Line-2A
	Work Place name/

Budget contents for 'rolling stock Maintenance'<mid term>
(CAPEX: Spare equipments & parts)

No.	Name	Detail	New purchases	Additional purchases	Item of expence	Distinction of expence	2015	2016	2017	2018	2019	2020	Possession quantity		Purchase reason
							Price	Price	Price	Price	Price	Price	Now	Plan	
						Quantity									
					CAPEX	Unit price									
						total									
						Quantity									
					CAPEX	Unit price									
						total									
						Quantity									
					CAPEX	Unit price									
						total									
						Quantity									
					CAPEX	Unit price									
						total									
						Quantity									
					CAPEX	Unit price									
						total									
						Quantity									
					CAPEX	Unit price									
						total									
						Quantity									
					CAPEX	Unit price									
						total									
						Quantity									
					CAPEX	Unit price									
						total									
Total						Quantity									
						Unit price									
						total									

Year/	2015-2020
Line name/	Line-2A

Budget contents for 'Facilities maintenance'<mid term>
(CAPEX: New car&mprovement , cost of wire-off: removal)

No.	Plan name	Implementation reason	Work place name	Item of expence	Distinction of expence	2015		2016		2017		2018		2019		2020	
						Quantity	Price	Quantity	Price	Quantity	Price	Quantity	Price	Quantity	Price	Quantity	Price
				CAPEX	Materials												
					Outsource												
					total												
				Wire-off	Outsource												
				CAPEX	Materials												
					Outsource												
					total												
				Wire-off	Outsource												
				CAPEX	Materials												
					Outsource												
					total												
				Wire-off	Outsource												
				CAPEX	Materials												
					Outsource												
					total												
				Wire-off	Outsource												
				CAPEX	Materials												
					Outsource												
					total												
				Wire-off	Outsource												
				CAPEX	Materials												
					Outsource												
					total												
				Wire-off	Outsource												
				CAPEX	Materials												
					Outsource												
					total												
				Wire-off	Outsource												
				CAPEX	Materials												
					Outsource												
					total												
				Wire-off	Outsource												
Total				CAPEX	Materials												
					Outsource												
					total												
				Wire-off	Outsource												

Year/	2015-2020
Line name/	Line-2A
Work Place name/	

Budget contents for 'rolling stock Maintenance'<mid term>
(CAPEX: Equipments for inspection)

No.	Name	Detail	New purchases	Additional purchases	Item of expence	Distinction of expence	2015	2016	2017	2018	2019	2020	Possession quantity		Purchase reason
							Price	Price	Price	Price	Price	Price	Now	Plan	
						Quantity									
					CAPEX	Unit price									
						total									
						Quantity									
					CAPEX	Unit price									
						total									
						Quantity									
					CAPEX	Unit price									
						total									
						Quantity									
					CAPEX	Unit price									
						total									
						Quantity									
					CAPEX	Unit price									
						total									
						Quantity									
					CAPEX	Unit price									
						total									
						Quantity									
					CAPEX	Unit price									
						total									
						Quantity									
					CAPEX	Unit price									
						total									
Total						Quantity									
						Unit price									
						total									

Budget contents for 'other expense'<for 1 year>

Year/	2015
Line name/	Line-2A
Work Place name/	

No.	Name of expense	Price	Remark
Total			

d. Form of situation report for accident and failure

Situation Report

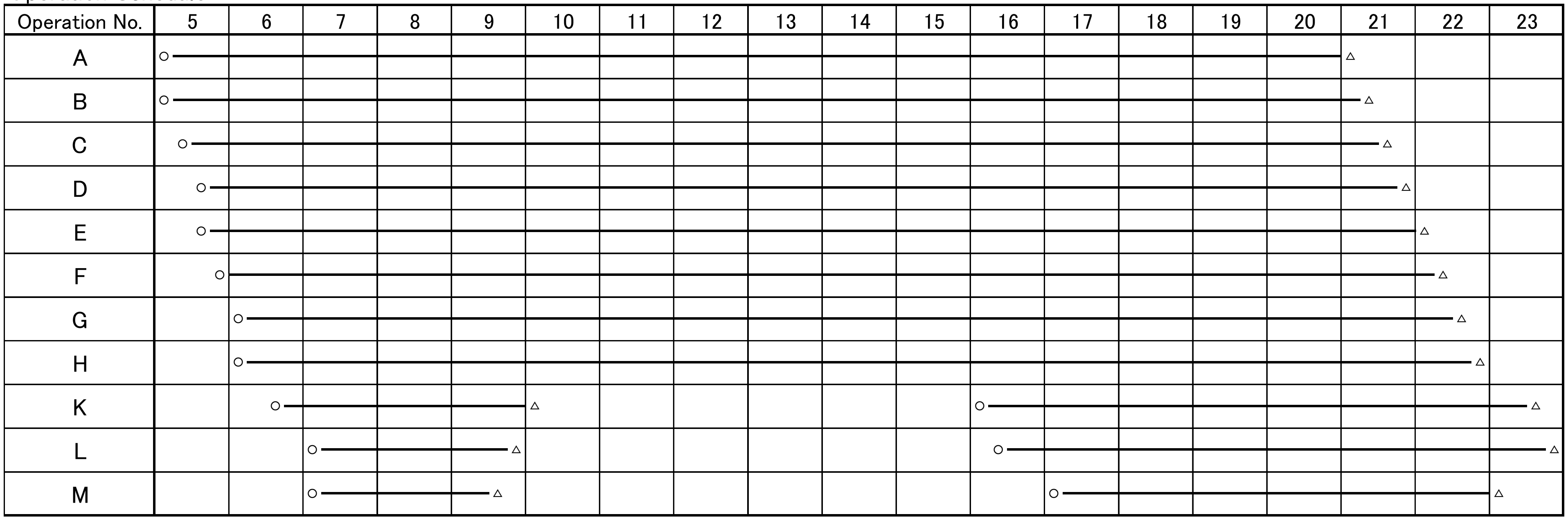
1. Creation Date	Year:		Month:		Date:				
2. Document No.									
3. Work place name									
4. Type	A	1. failure 2. accident 3. disaster 4. other							
	B	1. rolling stock 2. facility 3. driving 4. other							
5. Date and time of occurrence	Year:		Month:		Date:		Day of the week:		Weather:
6. Place of occurrence	Line:			–	Line:			Time	
	Station:				Station:				
7. Operation No.	No.:		Line:			–	Line:		
	Train set:		Starting station:				Destination station:		
8. Train No.									
9. Delay time	Delay: (min)		Stop operation:		–		Number:		
			Deadhead train:		–		Number:		
10. Specific date information of the train	Start operation		Recent improvement		Workshop improvement		Monthly inspection		Daily inspection
11. Occurance situation									
12. Contents of investigation									
13. Treatment for the time being									
14. Cause and analysis									
15. Measures to prevent recurrence	Preventive measures against recurrences:								
	Confirmation method of the effect:								
	Date of effect confirmation:								
16. Application of same measures to similar trains	Necessity: (Y or N)		Responsible work place:				Performed date:		

14) Attachment

Attachment-１ : Train allocation plan for Line-2A

1. Operation plan

Operation Schedule



○ Departure from Depot
△ Arrival to Depot
— Operating time

2. Inspection plan

Inspection plan (Monthly - train No. base)

	May																														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Train No.	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T
1																															
2	A	(M)	A	A	K	A	K	A	(L)	A	A	A	A		A	A	(M)	A	A	A	A		A	(L)	A	A	A	A	A	A	A
3	B	A	B	B	B	K			(M)	B	B	B	B	M	B	(L)	A	B	B	B	B	A	K	(M)	B	B	B	B	B	B	(L)
4							A	B	A	C	C	C	C	L	M	(M)	B	C	C	C	C	B	(L)	K	C	C	C	C	C	C	(M)
5	C	(L)	C	C	C	B	L	C						A	C	B	C	D	K	D	D	C	(M)	A	D	D	D	L		(L)	B
6	D	B	(M)	D	D	C	E	M	B	(M)	D	D	D	K	L						e	D	B	B	E	E	E	M	D	(M)	C
7	E	C	(L)	E	E	D	B	E	K	(L)	E	E	E	B	E	C	(L)	K	D	E	F	E							E	D	D
8	F	D	D	(M)	F	E	C	F	C	K	(M)	F	F	C	F	D	K	(M)	E	F	G	F	C	C	(M)	F	K	D	F		
9	G	E	E	(L)	G	F	D	L	D	D	(L)	G	G	D	G	K	D	(L)	F	G	H	G	D	D	(L)	K	F	E	G	E	E
10	H	F	F	F	(M)	G	M	G	E	E	F	(M)	H	E		E	E	E	(M)	H	L	H	E	E	K	(M)	G	F	H	F	F
11	K	G	G	K	(L)	H	F	H	F	F	G	(L)	K	F	L	F	F	F	(L)	K	K	M	F	F	F	(L)	H	G	M	G	K
12	L	H	K	G	H	(M)	G	D	G	G	H	K	(M)	G	d	G	G	G	G	(M)	M	L	G	G	G	G	(M)	H	L	K	G
13	M	K	H	H	A	(L)	H	K	H	H	K	H	(L)	H	H	H	H	H	H	(L)		K	H	H	H	H	(L)	K	K	H	H

Kinds of maintenance

5-year inspection

3-month inspection

( ) 10-day inspection

Creaning

Wheel grinding

Appendix8-6-6-1-B

Date	02/May
Day of the week	Mon

operation No. (11)	train No.	departure track No.	departure time		temp-arrival track No.	temp-arrival time		re-departure track No.	re-departure time		final arrival track No.	final arrival time
A	03	#01	5:00		-	-		-	-		#01	21:00
B	06	#02	5:10		-	-		-	-		#02	21:15
C	07	#03	5:20		-	-		-	-		#03	21:30
D	08	#04	5:30		-	-		-	-		#04	21:45
E	09	#05	5:40		-	-		-	-		#05	22:00
F	10	#06	5:50		-	-		-	-		#06	22:15
G	11	#07	6:00		-	-		-	-		#07	22:30
H	12	#08	6:10		-	-		-	-		#25	22:45
K	13	#09	6:40		#25	10:00		#25	16:00		#08	23:30
L	05	#10	7:00		#21	9:45		#21	16:15		#09	23:50
M	02	#11	7:10		#22	9:30		#22	17:00		#10	23:40

under inspection	train No.
8-year	-
4-year	01
3-month	04
10-days	02, 05
cleaning	13
wheel grinding	-

Attachment-2：Calcuration of the number of maintenance personnel of Line-2A

1. Maintenance staff of Line-2A according to training plan

Train check and repair department of Line 2A：53 person

In the train check and repair department of Line 2A, there are 6 Management Staff and 47 Werking staff. It includes 4 persons in Check and repair supervision team, 28 persons in Check teams by segment, 7 persons in Monthly maintenance team and 8 persons in General equipment. For detail, see following table.

Department	Staff classification	Position classification	Standard of staff arrangement	Number
Train check and repair department of Line 2A	Management Staff	Chief of check and repair department	1 person/department	1
		Deputy chief of check and repair department	1 person/department	2
		Senior Technical Manager of check and repair	1 person/department	1
		Chief engineer of check and repair	1 person/department	1
		Assistant of check and repair	1 person/department	1
	Check and repair supervision team	Check and repair supervision staff	1 person/shift, 4 teams 2 shifts	4
	Check teams by segment	Main segment check supervisor	1 person/shift, 4 teams 2 shifts	4
		Seniorelectrification check	1 person/shift, 4 teams 2 shifts	4
		Electrification check	2 person/shift, 4 teams 2 shifts	8
		Senior Equipment check	1 person/shift, 4 teams 2 shifts	4
		Equipment check	2 person/shift, 4 teams 2 shifts	8
	Monthly maintenance team	Monthly maintenance leader	1 person	1
		Senior monthly electrification maintenance	1 person	1
		Monthly electrification maintenance	2 person	2
		Senior monthly Equipment maintenance	1 person	1
		Monthly Equipment maintenance	2 person	2
	General equipment	Main supervisor to equipment	1 person	1
		Operator of machine type A（Crane truck）	1 person	1
		Operator of machine typeB（Roller）	1 person	1
		Operator of machine typeC（Train washing machine）	1 person	1
		Supervision of Equipment Type A（Measurement tool）	2 person	2
		Supervision of Equipment Type B（small train, train repair）	2 person	2
	Total			53

2. Verification of the number of maintenance personnel of Line-2A

<u>Premise</u>

Inspection is carried out as proposed by contractor.

・Monthly inspection<working sift : day−time>
 Contents of inspection is same as 3−months inspection(conducted by Tokyo Metro)

・Daily inspection<working shift: 3shift/day(Ban−san's 4−group idea)>
 Contents of inspection is same as 10−days inspection(conducted by Tokyo Metro)

・number of train sets
 13 train sets

<u>Assumption for adequate number of staffs</u>

	Classification		Remark
	Management staff	Working staff	
Maintenance in office	6		
Monthly inspection	2		
		5	In Tokyo Metro(6cars/1day→about 15staffs) In this case (4cars/2day→about 5staff) <calculation 15staff * 4/6cars * 1/2day> ※There are 13 train sets, and 26weekdays(mon〜sat) in one months, so it is sufficient to inspect 1train set/2days)
Daily inspection	2*4group=8		
		4*4group=16	It is implementated with 3−shifts. It is necessary to have 4 team for 3−shits. And it is necessary to have 4 staffs for 1 shift. <calculation:4staffs * 4teams> ※All 13 train sets are inspected everyday.
Other maintenance	1	5	assumed by example of Tokyo Metro
General equipment	1	7	
total	18	33	
	51		

Attachment-3: Overview of Rolling Stock of Line-2A

- There are 52 cars / 13 trains. Propulsion systems, braking systems, train signaling equipment, radio equipment etc. are included under supply of equipment for the trains.
- Spare equipment and corrective maintenance tools (connection tools, assembly tools, etc).
- Replace perishable and ealily worn components once during the warranty period.
- Including the cost of installing and testing the system propulsion system, braking system etc.
- Technical documentation and drawings.

The main dimensions of the train requirements table (calculated unit: mm)

The train length The length between Coupler connection surfaces)	Tc rolling stock: 19520+500（Temporary） M rolling stock: 19520
Train length (the length between Coupler connection surfaces of two sides in the Four-Rolling stock train)	79080（Temporary）
Body train length	Tc rolling stock: 19500（Temporary） M rolling stock : 19000
Rolling stock height (From the track surface to the top of the train, new wheels)	3800
The maximum width of the Rolling stock	2800
Central height of the inside Rolling stock (Non-dynamic height in the passenger rolling stock):	2100
The minimum height of the standing area in the passenger rolling stock	1900
Air spring is inflated, the floor surface to the height of the rail surface	1100
Bogie center distance	12600
Bogie fixed wheelbase	2200
The coupler centerline from the height of the rail surface	660+10
Wheel diameter:	
New car	840+10
Half-worn wheel	805
Abrasion wheel	770
Wheel on the inside pitch	1353±2
Passenger compartment side doors	
Side door logarithm	4 pairs / side rolling stocks
Side door opening width	≥1300
Open the side door, the height above the threshold of the top surface	≥1800
Cab side door	≥600
Net cab side door open width	
Cab side door is open, the threshold above the top surface height	≥1800
Through Road (no partition doors)	
Through the channel width	≥1200
Through the channel height	≥1850

Attachment -4: Contents of training for Maintenance Personnel of Line-2A

Train maintenance class (theory 25 days)							
Week 1	Day	Mon	Tue	Wed	Thu	Fri	Sat
	Morning 9:00—12:00	General about train	Train electric equipment layout	Train electric equipment layout	Tractive and leading system	Tractive and leading system	Tractive and leading system
	Afternoon 14:00—17:00	General about train	Train electric equipment layout	Train electric equipment layout	Tractive and leading system	Tractive and leading system	Tractive and leading system
Week 2	Day	Mon	Tue	Wed	Thu	Fri	Sat
	Morning 9:00—12:00	Tractive and leading system	Tractive and leading system	Tractive and leading system	Auxiliary system	Auxiliary system	Braking system
	Afternoon 14:00—17:00	Tractive and leading system	Tractive and leading system	Tractive and leading system	Auxiliary system	Auxiliary system	Braking system
Week 3	Day	Mon	Tue	Wed	Thu	Fri	Sat
	Morning 9:00—12:00	Braking system	Braking system	Braking system	Braking system	Air condition and heating system	Bogie
	Afternoon 14:00—17:00	Braking system	Braking system	Braking system	Braking system	Air condition and heating system	Bogie
Week 4	Day	Mon	Tue	Wed	Thu	Fri	Sat
	Morning 9:00—12:00	Bogie	Bogie	Through line	Statement of using door next to passenger chamber	On-board braking system	Passenger informatio n system
	Afternoon 14:00—17:00	Bogie	Bogie	Statement of using door next to passenger chamber	Statement of using door next to passenger chamber	On-board braking system	Reviewing
Week 5	Day	Mon	Tue	Wed	Thu	Fri	Sat
	Morning 9:00—12:00	Reviewing					
	Afternoon 14:00—17:00	Taking an exam					

Practical timetable of vehicle maintenance						
Week	Time	Training method for positions				No. of days
		Management staff	Maintenance and	Monthly inspection	Equipment general	
Week 1	9：30～ 16：00	Education before practice				6 days
Week 2	9：30～ 16：00	Practice at inpection	Practice at inpection	Practice at monthly	Practice at equipment	6 days
Week 3	9：30～ 16：00	Practice at inpection	Practice at inpection	Practice at monthly inpection	Practice at equipment general class	6 days
Week 4	9：30～ 16：00	Practice at monthly inpection	Practice at inpection	Practice at monthly inpection	Practice at equipment general class	6 days
Week 5	9：30～ 16：00	Practice at equipment	Practice at inpection	Practice at monthly	Practice at equipment	6 days
Week 6	9：30～ 16：00	Practice at technical team of maintenance center	Practice at inpection	Practice at monthly inpection	Practice at equipment general class	6 days
Week 7	9：30～ 16：00	Reviewing, taking an exam				4 days

Hanoi City People's Committee
Hanoi Railway One-Member Limited Liability Company

Socialist Republic of Vietnam
Independence Freedom Happiness

Regulation on Civil Structure Maintenance

Chapter 1: Purpose

Chapter 2: Applicable Scope and Target

Chapter 3: Definition of Terms and Abbreviations

Chapter 4: Legal Foundation and Reference Materials

4.1 Legal Foundation

4.2 Reference Materials

Chapter 5: Responsibility for Implementation

Chapter 6: Structure of Implementation and Management Organization

6.1 Management Organization Structure of Civil Structure Maintenance Section at HQ and OU

6.2 Stratification of Implementation of Work

Chapter 7: Regulations on Document Storage

Chapter 8: Forms and Appendices

Chapter 1: Purpose

This document has been edited to describe regulations concerning civil structure maintenance procedures for various types of equipment and systems that comprise an urban railway.

Maintenance of an urban railway to keep it in constant good operational condition so that it does not stop for any unexpected reasons. In addition, it is important for the urban railway to continue high-density operation without delays. However, the equipment inevitably deteriorates due to repeated use. This is an unavoidable fact that should always be kept in mind by maintenance staff. Despite the above, the urban railway must continue operations according to the plan once operations are started. This method of business will enhance users' recognition of the urban railway as a trustworthy means of transportation, and will most possibly increase the number of users.

Among the various types of urban railway equipment, this document focuses on maintenance of civil structures, and classifies related work into three categories: inspection, planning, and repairs.

Every item related to civil structures must be maintained in good condition, every potential failure must be prevented using appropriate measures, and necessary repairs must be carried out on a timely basis using suitable measures in order to ensure safe and continued urban railway operations, and to maintain the relevant structures in sound condition.

Chapter 2: Applicable Scope and Target

- This regulation stipulates the requirements for maintenance of civil structures of the respective urban railway lines in the city of Hanoi.
- This regulation applies to the organizations and individuals who are directly engaged in maintenance of civil structures in respective urban railways in the city of Hanoi.
- Applicable scope: The applicable shall be the respective urban railways administered by Hanoi Metro Company.

Chapter 3: Definition of Terms and Abbreviations

The Regulation on Civil Structure Maintenance covers the procedures for inspection, planning and repair work, the contents of this work, and the guidance on implementation of the work.

- **Maintenance** denotes the respective activities (inspection, follow-up, planning and repair) that are implemented regularly or irregularly according to the design requirements in order to maintain civil structures in conditions suitable for normal operation and use.
- **Inspection** refers to checking of relevant structures for signs of failure either visually or by use

of special equipment in order to judge the acceptability of the current state.

- **Planning** means formulating appropriate repair plans based on the inspection results to ensure safe train operation and safe use of the civil structures.
- **Repair** denotes the act of recovering from a failed state in order to ensure the safety of the relevant civil structures while trains are in operation or in use. In this case, maintenance shall be executed appropriately in accordance with the formulated maintenance plan.
- **Upgrading** denotes replacing an existing item of equipment with a new one, or adding a new item of equipment to an existing one when it is not possible to completely recover its functionality by repeated repairs alone.

Chapter 4: Legal Foundation and Reference Materials

4.1 Legal Foundation

- National Law on Civil Engineering Work No. 50/2014/QH13 dated 2014/6/18
- Decree No. 114/2010/NĐ-CP on Maintenance of Civil Structure dated 2010/12/06
- Traffic and Transportation Ministry Circular No. 20/2013/TT-BGTVT on Management and Maintenance of Railway Facilities dated 2015/08/16
- Decree No. 46/2015/NĐ-CP on Quality Control of Civil Structure dated 2015/05/12
- Decree No. 32/2015/NĐ-CP on Management of Construction Investment Costs dated 2015/03/25
- Labor Law by Diet No. 10/2012/QH13 dated 2012/06/18

4.2 Reference Materials

- Documents and materials from 2A Line work
- Basic Standard No. TCCS 01: 2010/VNRA on Maintenance Procure of Railway Viaductss and Tunnels
- Our experience gained from maintaining civil structures of subways in Tokyo

Chapter 5: Responsibility for Implementation

- Staff who maintain civil structures shall receive the necessary education that will equip them with the necessary knowledge and skills to carry out their assignments.
- Staff who maintain civil structures shall carry out their assignments unfailingly to maintain reliable and safe operations that are not stopped due to unexpected reasons.
- When concluding an agreement on inspections or repairs with a subcontractor, the maintenance

staff shall confirm that the subcontractor has sufficient capabilities to execute the assigned business.

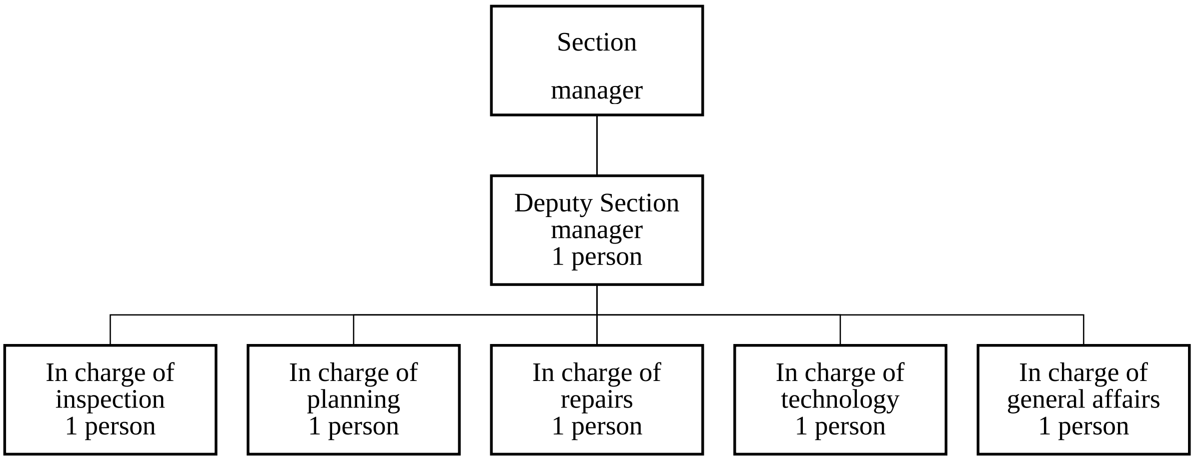
Chapter 6: Structure of Implementation and Management Organization

- While the train is in operation or in use, civil structures shall be maintained according to regulations.
- The civil structure maintenance procedure shall be formulated, along with the design standard, based on the maintenance regulation herein.
- Maintenance of civil structures shall assure safety of those who engage in the work as well as the property.

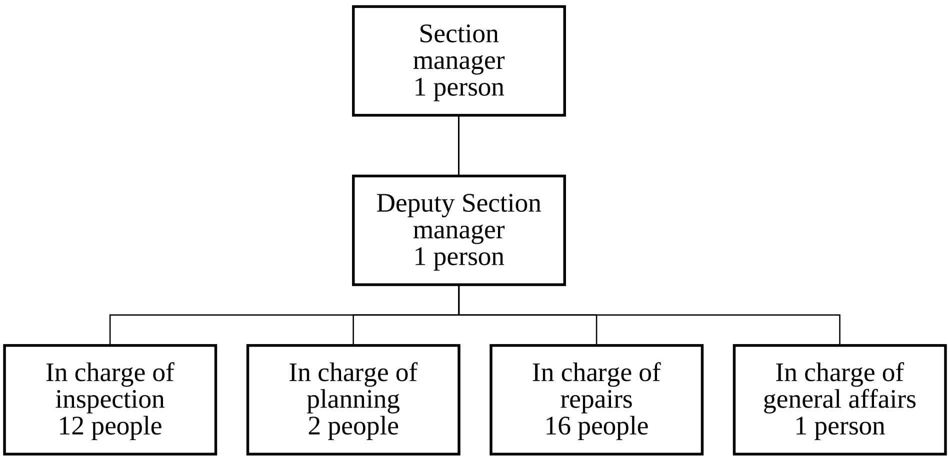
  (The maintenance staff must prepare suitable protective gear, tools and machines before starting the inspection or repair.)

6.1 Management Organization Structure of Civil Structure Maintenance Section at HQ and OU

Headquarters (HQ)



Operation Unit (OU)



6.2 Stratification in Implementation of Work

a. Headquarters (HQ)

HQ shall assume the management function.

- Manages the inspection work of OU
- Checks the civil structure maintenance plan of OU
- Formulates the civil structure maintenance plan of all lines
- Implements the operations related to the bid tender and outsourcing agreement for civil structures of respective lines.
- Formulates the personnel program for civil structure maintenance work at OU.
- Checks the civil structure maintenance procedure of OU.
- Checks the design and the civil structure maintenance costs of OU.
- Administers the material supply and parts use plan of OU.
- Implements administration, auditing and acceptance inspections on every civil structure maintenance job carried out on respective lines.
- Formulates the rules, technical standard system and technical procurement for civil structure maintenance.
- Submits approval request forms related to civil structure maintenance work to the regulatory authority.
- Formulates accident processing measures by analyzing and verifying the given accident.
- Studies how to improve the maintenance methods.
- Implements the work related to design and improvement of the maintenance equipment for civil structures.

b. Operation Unit (OU)

OU shall assume the role of implementing the actual work.

- Carries out the inspection work from the OU standpoint.
- Formulates the civil structure maintenance plan of the assigned project, reports and submits the related approval request form.
- Creates the bid tender plan and the outsourcing agreement concerning maintenance of civil structures, and submits the approval request form for these.
- Makes suggestions and proposals related to the bid tender and outsourcing agreement for civil structures of respective lines in quality of OU.
- Proposes the personnel program for civil structure maintenance work in quality of OU.
- Finalizes necessary civil structure maintenance jobs and calculates maintenance costs.
- Finalizes OU's demand for materials to be supplied, and use of parts.
- Implements civil structure maintenance, and conducts internal audit and acceptance inspections

on the maintenance work.

- Conducts acceptance inspections of completed or uncompleted civil structure maintenance work in collaboration with HQ.
- Tabulates and analyzes accidents, and submits comments on the accidents to HQ.
- Proposes improvements for equipment used for civil structure maintenance.

c. Hanoi Metro maintenance staff

- Inspections and repair work are carried out in three shifts.

  1st shift: 6:00 start - 15:00 end

  2nd shift: 14:00 start - 23:00 end

  3rd shift: 22:00 start - 7:00 end

  + Workers work 8 hours in each shift. (1-hour break period is included in the above. This 1-hour period not be included in the duty period.)
  + 1-hour is duplicated between each shift for the hand-off from the preceding to the succeeding unit. (The last 1-hour of the preceding unit and the first 1-hour of the succeeding unit is used for the hand-off.)
- The Unit Chief of each shift shall judge any work-related defects according to the Defect Judgment Criteria. He shall record details of the judgment on the Inspection Record.
- The Unit Chief of the preceding shift hands off the completed and uncompleted jobs as well as necessary tools, if any, to the Unit Chief of the succeeding shift. The above matters shall be described in the Hand-off Record.
- When the maintenance plan is not executable as scheduled due to the reasons such as missing staff, bad weather, etc., Unit Chief of each shift shall choose the location where the work can be done referencing the monthly plan, or adjust the workload of the day's maintenance plan.
- Hand-off between shifts
  + The preceding shift hands off the implemented work to the succeeding shift (completed and uncompleted jobs in the day's maintenance plan).
  + The preceding shift hands off the machines and tools to the succeeding shift (when they are used by the succeeding shift, too).
  + After the work is completed, the shift that used the machines and tools must return them to the specified places.

● **Inspection and Repair staff**

- Inspection staff

The person responsible for the inspection results [Unit chief]	1 person

Person in charge of inspection (staff)	2 people

When a visual inspection is not possible for the given location, a service vehicle for high-elevation work shall be used.

\+ Inspection staff when a service vehicle for high-elevation work is used

Worker to drive service vehicle used for high-elevation work control the up-and-down movement and lighting	1 person
The person responsible for the inspection results	1 person
Person in charge of inspection	1 person

\- Repair staff

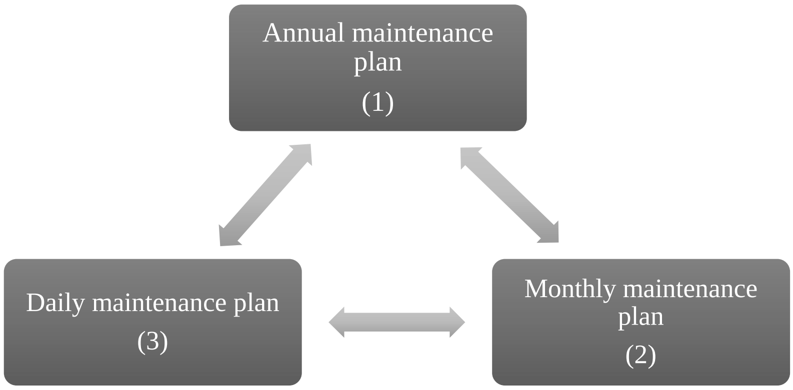
Driver	1 person
The person responsible for safety	1 person
Person in charge of maintenance	2 people

d. Staff for Formulation of Plan

Based on the inspection results, the person in charge of planning formulates the maintenance plan and sends it to the person in charge of repairs. The person in charge of repairs checks its feasibility. If not feasible, the person in charge of planning must revise it as appropriate.

- [Person in charge of planning] is responsible for formulating the annual and monthly maintenance plans.
- [Unit chief] is responsible for formulating the day's maintenance plan.

Defects that are not included in the maintenance plan shall be updated in the next monthly or annual maintenance plan.



- **Application procedure**

HQ

- HQ Section manager: Responsible for everything concerning the plans developed at HQ and OU. When not available, the duty may be delegated to HQ Deputy Section manager.
- HQ Deputy Section manager: Responsible for each person in charge at HQ and OU, and summarizes the jobs in progress and reports them to the Section manager. When not available, the duty may be delegated to each person in charge.
- Each person in charge at HQ: Responsible for the jobs at HQ and OU, and reports them to the Section manager and Deputy Section manager.
- Person in charge of general affairs at HQ: Responsible for retention of the documents and general affairs.

OU

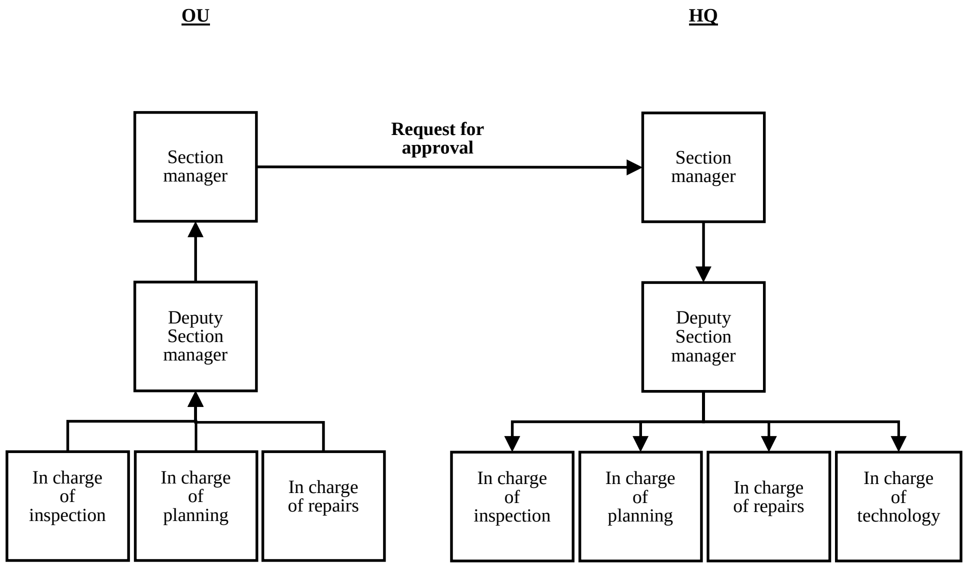
- OU Section manager: Responsible for everything concerning the plans developed at OU. When not available, the duty may be delegated to OU Deputy Section manager.
- OU Deputy Section manager: Responsible for work of each unit of OU, and summarizes the jobs in progress and reports them to the OU Section manager. When not available, the duty may be

delegated to the Unit Chief of each unit of OU.

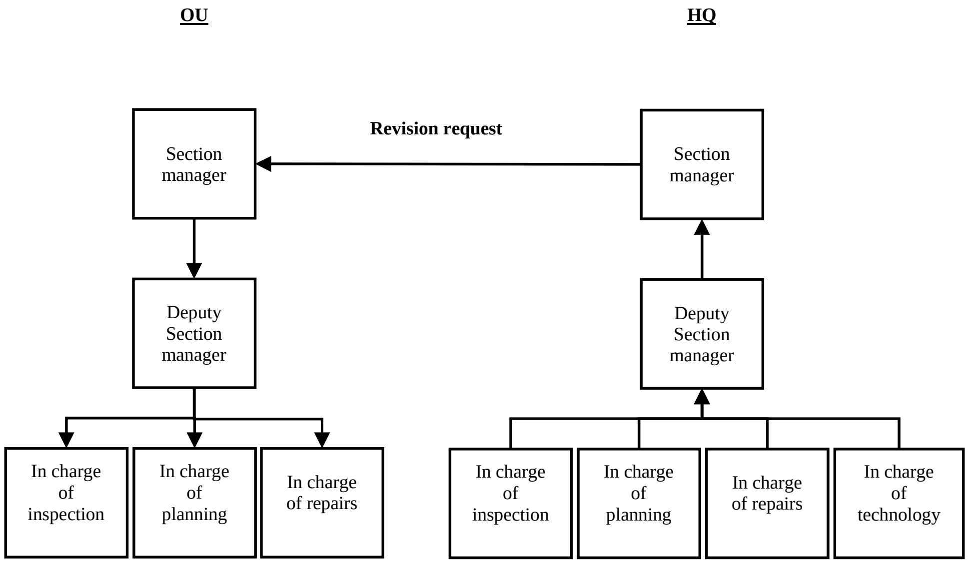
- Unit Chief of each unit in charge at OU: Responsible for each unit he is in charge of, and reports them to the Section manager and Deputy Section manager of OU.

- **Plan and Work Reporting and Approval Procedure (From OU to HQ)**

- Each person in charge at OU submits the report to the senior office of the section. After gaining approval, the above person sends it the senior officer of HQ. Then, the above person sends it to the unit in charge at HQ for verification. After inspection and confirmation, the above unit in charge sends the document to the senior officer of HQ for approval. Then the above unit sends it to OU for implementation.



- If any revisions are needed, HQ requests the senior officer of OU to revise the document or conduct a re-inspection. Then, HQ sends the request again to each OU unit for revision.



- **List of Portion that Require Maintenance**

- Portions that belong to structure
  + Building, stations and equipment that belong to civil structure
  + List of fire extinguishing equipment
- Portions that belong to civil structures
  + Viaductss and tunnels

- **Inspection Cycles (Application to Hanoi Metro Company is proposed)**

- Viaducts inspection cycle

Inspection cycle	Inspection method	Note
3 times/month	Check viaductss by walking quickly with the rest of the patrol.	
Once/2 years	Check the target locations using a service vehicle for high-elevation work and, if cracks are detected, record their details.	Finalize the evaluation of the following items. + Inspection of area in the vicinity of the viaducts + Place and dimension + Cause + Crack progress state + Judgment on influence of cracks

Extraordinary inspection	When the following accidents occurred, OU and HQ shall collaborate in inspecting and evaluating the current state and promptly developing countermeasures. Such events may include unexpected accidents that affect safe use of structures or safe train operations, accidents due to disasters such as typhoons, floods, earthquakes and fire hazards, and sudden train-related accidents.	

Results of the above inspection are recorded and reported to the person who has formulated the maintenance plan.

- Tunnel inspection cycle

Inspection cycle	Inspection method	Note
Every month	Check the tunnel visually while walking through it during the time period when trains are not running. No lighting.	
Once/1 years	Check the tunnel visually using the lamp during the time period when trains are not running.	Finalize the evaluation of the following items. + Place and dimension + Cause + Crack progress state + Judgment on influence of cracks
Once/10 years	Check the tunnel in detail using the lamp during the time period when trains are not running. Inspect the tunnel ceiling using the service vehicle for high-elevation work.	
Extraordinary inspection	When the following accidents occurred, OU and HQ shall collaborate in inspecting and evaluating the current state and promptly developing countermeasures. Such events may include unexpected accidents that affect safe use of structures or safe train operation, accidents due to disasters such as typhoons, floods, earthquakes and fire hazards, and	

	sudden train-related accidents.	

Results of the above inspection are recorded and reported to the person who has formulated the maintenance plan.

Chapter 7: Regulations on Document Storage

- The following describes the burden sharing and implementation procedures concerning storage of the documents and materials (materials related to inspection, plan and repair) for civil structure maintenance.
- The materials to be saved must be originals (described on papers, and in movies and photos). When the original is not available, a legitimate copy shall be saved.

Retention period

(Documents are retained in accordance with Interior Ministry Circular No.09/2011/TT-BNV on the retention period of documents and materials dated 2011/06/03.)

Materials	Retention period	Department in charge of maintenance (Section in charge of general affairs)
Documents on basic construction to be sent to the authority concerned. (In document form as a general rule)	Up to expiration date of effect and force	- OU - HQ
Documents for system formulation, regulations on basic policy formulation of the authority concerned and documents related to guidance.	No set duration	- OU - HQ
Plan documents and reports of the basic construction investments. - Long period, Fiscal year - Six months, Nine months - Quarter term, Monthly	- No set duration - 20 years - 5 years	- OU - HQ
Documents related to basic civil structures. - Documents related to structures of A group, structures that introduce unprecedented architecture, construction, technology, equipment and materials, structures that are erected in special geological conditions or on special geological forms, and structures that are recognized as	- No set duration	- OU - HQ

cultural and historical assets.		
Documents related to structures of B and C groups and documents related to large-scale repairs.	Dependent on the life of the given civil structure	- OU - HQ
Documents related to small-scale repair of structures.	15 years	- OU - HQ
Conference documents on basic construction.	10 years	- OU - HQ

Forms that must be prepared

Order	Form name	Number (When assigned)
1	Table of contents of a submitted/preserved document	
2	Record of a submitted/preserved document	
3	Table of contents of a document	
4	Request for disposal of preserved documents	
5	Letter of introduction	
6	Request for use of preserved edition	

Chapter 8: Forms and Appendices

Defect Judgment Criteria

Class		Structure soundness judgment criteria
A		Existence of an abnormality that threatens the following. - Operational security - Normal train operations - Public safety Or an abnormality that potentially threatens to compromise the above.
	AA	Existence of an abnormality that threatens the following. - Operational security - Normal train operations - Public safety - An abnormality that requires emergency measures Repair period: Train must be stopped immediately.
	A1	- An ongoing abnormality is deteriorating the performance of a structure. - Structural performance can be completely lost due to heavy rains or flooding. Repair period: Must be repaired immediately during the night of the day it occurred.
	A2	- An existing abnormality threatens to deteriorate performance of a structure in the future. Repair period: Within a year from the day of inspection
B		- Existence of an abnormality that threatens to grow to soundness A in the future.
C		- A portion of a structure that has a slight abnormality.
S		- Sound portion of a structure

Inspection Record Form
Hanoi Railway One-Member Limited Liability Company
Civil Structure Preservation Section
Inspection Record

(Year and date)

Supervisor	Unit Chief

Type of inspection	Contents of inspection	Number

Line	Station	Place	Defect judgment

Inspection method	(Hammering, visual inspection, etc.)
Type	(Crack, peeling, bulge)
Cause	
Processing method	(Repair or further monitoring)

Inspection date	Defect state	Defect judgment	Deadline of defect repair

Defect state

Hand-off Record

Hanoi Railway One-Member Limited Liability Company
Civil Structure Preservation Section

(Year and date)

Unit to hand off the work: …………… A/Hanoi Metro Civil Structure Preservation Section

Unit to take over the work: …………… B/Hanoi Metro Civil Structure Preservation Section

Line	Place	Hand-off duration	Number of staff (Unit to hand off the work)	Weather

Contents of handed-off work
- Assignment

Assignment name	Maintenance plan	Completed	Not completed	Note

- Machines and tools

Name of machines	Number of machines	Note

Hanoi City People's Committee

Japan International Cooperation Agency

Project of Reinforcement of Urban Railway Regulatory Agency and Establishment of Operating Company in the City of Hanoi

Track Maintenance Regulations

Prepared by: **Hoang Tuan Dat**

TA Specialist: **Mr. Fujioka**

Contents

1. Purpose

This document provides requirements for track maintenance to assure the quality and structure of tracks, ensure safety operations, reduce the number of failures, and provide economic benefits.

2. Scope of Application

This document shall apply to any workplace that is involved in operational and maintenance activities of urban railways.

3. Definition of Terms and Interpretation of Abbreviation

- "Gauge" is the minimum distance between the rail heads in a section in which the track center line is straight.
- "Main track" is a track on which a train runs to provide passengers with service according to a train operation schedule.
- "Side track" is a railroad track (including a depot), not a main track.
- "Station" is a place where trains load or unload passengers where trains can be moved from one track to another using turnouts and crossings. A depot is also referred to as a "station".
- "Car" is a railway passenger that is mainly used for railway operations, or a dedicated car (a track geometry car, an electrical inspection car, a relief car, or a car with a special structure or facilities) with the exception of a track maintenance car.
- "Train" is a series of connected railroad cars that satisfies all critical conditions for safe train operations from a station to another station according to a transport plan, including the number of connected vehicles and braking force.
- "Railway signaling" refers to a signal, a sign, or sign markers.
- "Signal" is a railroad facility used to indicate the operating condition of a train or car to a driver or other people involved in operations.
- "Sign" is way to communicate among the railway staff via geometry, coloring, voice, etc.
- "Sign markers" are signs that indicate locations, directions, conditions, or the like to relevant crews, workers or the like.
- "Outside the Station" refers to the outside of the station limit.
- "Station limit" is a section situated between the outer-most sign marker (direction in which a train approaches) in a station yard and the outer-most sign marker (direction in which a train departs) in the station yard.
- "Track maintenance" is the upkeep of track functions and efficiency. It involves technical work to appropriately restore functions and efficiency that are degraded due to use of tracks.
- The basic components of track include (1) rails, (2) joints, (3) sleepers, (4) rail fastening system, (5) antivibration devices, (6) ballast track beds, (7) concrete beds, (8) turnouts and crossings, (9) stoppers, and (10) sign markers.
- Track maintenance is carried out through the following stages: (1) inspection of tracks, (2) development of maintenance plan, and (3) implementation of track maintenance (daily maintenance, frequently occurring repairs repairs, moderate scale repairs, large scale repairs, renewal).

4. Legal Foundation and Relevant Materials

4.1 Legal Foundation

The provisions in the Regulations shall be in compliance with the laws and regulations of Vietnam. MOT is currently preparing the regulations and standards concerning operation and maintenance of urban railways. When these regulations and standards have been established, the Regulations must be updated.

4.2 Relevant Materials

- Vietnam Railway Act 2005
- Circular No.20/2013/TT-BGTVT dated August 16, 2013 on Regulations on Management and Maintenance of Installation of Railway
- Ordinary Railway Structures Maintenance Standard TCCS 02:2014/VNRA
- Seamless Railway Facilities Maintenance Standard TCCS 03:2014/VNRA
- Standard TCCS 05:2014/VNRA on Resources, Materials and Accessory Items used in Railway

Maintenance Work

5. Responsibility for Implementation

Each HMC workplace and each HMC personnel involved in the track maintenance is responsible for complying with the regulations.

6. Details of Regulations

6.1 Regulations on Track Inspections

6.1.1 Inspection Services

- Train patrol
- Patrol on foot
- Inspection of structure gauge
- Inspection of tracks
- Inspection of turnouts and crossings
- Guardrail inspection
- Joint inspection
- Expansion joint inspection
- Inspection of sleepers
- Inspection of fastening system
- Inspection of vibration
- Inspection of track bed
- Car stop inspection
- Sign marker and indicator inspection

6.1.2 Regulations on Inspections and Inspection Periods

- Train patrol

  The main tracks must be patrolled at least once per month to check for train noise and abnormal vibrations.
- Patrol on foot

  A patrol on foot must be carried out in all sections of the main tracks and side tracks at least three times per month to check the conditions of track maintenance.
- Inspection of structure gauge

  The inspection of structure gauge must be carried out at least once per year in all sections of the main tracks and side tracks to ensure that there are no facilities that exceed the structure gauge.
- Inspection of tracks
  + Measurement of a distance of both tracks

    The measurement of a distance of both tracks must be carried out at least once per year at pre-determined measurement points for both the main tracks and side tracks to ensure that the required track spacing is as specified.
  + Gauge measurement

    Gauge measurement must be carried out at least twice per year in all sections of the main tracks and at least once per year in all sections of the side tracks to ensure that the gauge has neither increased nor decreased over a specified limit.
  + Measurement of cross level

    Measurement of cross level must be carried out at least twice per year in all sections of the main tracks and at least once per year in all sections of the side tracks to ensure that the cross level has neither increased nor decreased over a specified limit.
  + Measurement of alignment

    Measurement of alignment must be carried out at least twice per year in all sections of the main tracks and at least once per year in all sections of the side tracks to ensure that the alignment has neither increased nor decreased over a specified limit.
  + Measurement of longitudinal level

    Measurement of longitudinal level must be carried out at least twice per year in all sections of the main tracks and at least once per year in all sections of the side tracks to ensure that the longitudinal level has neither increased nor decreased over a specified limit.
  + Measurement of twist

Measurement of twist must be carried out at least twice per year in all sections of the main tracks and at least once per year in all sections of the side tracks to ensure that twist has neither increased nor decreased over a specified limit.

+ Inspection of rail

Inspection of rail must be carried out at least twice per year in all sections of the main tracks and at least once per year in all sections of the side tracks to check top surfaces of rails for damage, including wearing depth, flaking and shelling, and to check welded joints of rails for irregularities.

+ Inspection of turnouts and crossings

- Inspection of parts

  The Inspection of turnouts and crossings parts must be carried out at least twice per year for all turnouts and crossings of the main tracks and at least once per year for all turnouts and crossings of the side tracks to check tongue rails for engagement, to check top surfaces of rails for damage, including wear, flaking and shelling, and to check welded joints of rails for irregularities.

- Measurement of spacing between parts

  Measurement of spacing between turnout and crossing parts must be carried out at least twice per year for all turnouts and crossings in the main tracks and at least once per year for all turnouts and crossings in the side tracks to ensure that neither the guard face gauge nor check gauge has increased or decreased over a specified limit.

+ Guardrail inspection

- Inspection of guardrail conditions

  Inspection of guardrail conditions must carried out in all sections of the main tracks and side tracks at least once per year to verify the spacing between guardrails and rails and fastening of attachments.

+ Joint inspection

- Joint gap inspection

  Joint gap inspection must be carried out at least twice per year for all joints of main tracks and at least once per year for all joints of side tracks to ensure that no joint gap has either increased or decreased over a specified limit.

- Inspection of joint conditions

  Inspection of joint conditions must be carried out at least twice per year for all joints of the main tracks and at least once per year for all joints of the side tracks to check for joint depressions, rail misalignment at joints, and unevenness in height at joints.

- Joint parts inspection

  Joint parts inspection must be carried out at least once per year for all joints of the main tracks and side tracks to ensure that joint bars and joint bar bolts have not been damaged.

+ Expansion joint inspection

- Inspection of expansion joint conditions

  Inspection of expansion joint conditions must be carried out at least twice per year for all joints of the main tracks and side tracks to ensure that none of the gauge, cross level, longitudinal level and alignment has increased or decreased over specified limit, and to verify the condition of stroke and contact.

- Expansion joint parts inspection

  Expansion joint parts inspection must be carried out at least twice per year for all joints of the main tracks and side tracks to check top surfaces of rails for damage, including wear, flaking and shelling, and to check welded joints of rails for irregularities.

+ Inspection of sleeper

- Inspection of sleeper conditions

  Inspection of sleeper conditions must be carried out at least once per year in all sections of the main tracks and side tracks to verify the spacing between sleepers and laying of accessories.

- Sleeper parts inspection

  Sleeper parts inspection must be carried out at least once per year in all sections of the main tracks and side tracks to ensure that there are no cracks or any other type of damage that may negatively affect sleepers.

+ Inspection of fastening system

- Inspection of rail fastening system conditions

  Inspection of rail fastening system conditions must be carried out at least once per year in all sections of the main tracks and side tracks to check the rail fastening system for looseness, loss, and any protruding track pads.

- Rail fastening system parts inspection

Rail fastening system parts inspection must be carried out at least once per year in all sections of the main tracks and side tracks to check for breakage, corrosion and any other damage.

+ Measurement of carbody vibration

  Measurement of carbody vibration must be carried out at least four times per year in all sections of the main tracks to ensure that the lateral and vertical acceleration has not exceeded a specified limit.

+ Inspection of track bed
  - Inspection of ballast conditions

    Inspection of ballast conditions must be carried out at least once per year in all sections of the main tracks and side tracks to verify the maintenance of cross section with ballast layer in ballast sections.
  - Ballast parts inspection

    Ballast parts inspection must be carried out at least once per year in all sections of the main tracks and side tracks to ensure that ballasts are not abraded over a specified limit and to ensure that there are no dangerous cracks or any other type of damage in the sections of concrete beds.

+ Inspection of car stop
  - Inspection of parts

    Inspection of parts must be carried out at least once per year for all car stops of the main tracks and side tracks to ensure that there are no cracks or or any other type of damage that may negatively affect car stops.
  - Functional inspections

    Functional inspections must be carried out at least once every seven years for all hydraulic car stops of the main tracks and side tracks to ensure that hydraulic car stops function normally.

Note:

Extra inspections must be carried out when it is necessary to urgently verify the conditions of tracks in the event of a disaster, such as a fire, earthquake, and flood or an abnormal accident, and when it is necessary to inspect the tracks in greater detail through regular inspections.

6.1.3 Inspection Results

- Inspection results shall be documented.
- The inspection document shall be created on the record forms in the Appendix in the Track Maintenance Manual.
- Inspection results shall be used to develop a track maintenance plan and shall be correctly stored in a document that identifies the conditions of facilities.

6.1.4 Tolerances

Tolerances are defined in detail in the track maintenance manual.

6.2 Regulations on Development of Track Maintenance Plans

The person in charge of planning shall formulate a maintenance plan based on inspection results and shall send it to the person in charge of repairs. The person in charge of repairs shall verify its feasibility. If not feasible, the person in charge of planning shall revise it appropriately.

The person in charge of planning shall be responsible for formulating annual and monthly maintenance plans. Unit Chief in charge of repairs shall be responsible for formulating day's maintenance plan.

6.2.1 Classification of Track Maintenance Plans

The track maintenance plans include a long-term plan (30-year plan), a medium-term plan (5-year plan) and a plan for the next year (annual plan).

30-year plan

A 30-year plan shall be formulated to spread enormous upgrade costs across the entire business without threatening safety urban railway operations. In the process of formulation, we can gain an understanding of the trends in the repair and upgrade costs within the entire business. We must also prepare a long-running employment policy based on the long-term plan.

Every item of urban railway equipment must eventually be replaced. If, however, replacement of a large number of items of equipment is required at the same time, we must prepare an enormous amount of funds. Therefore, in addition to the size of annual repair costs, we must coordinate and clearly describe the size of investment costs for equipment upgrades in the long-term plan based on the durable years of each item of equipment being set during the design phase, and the current state of the equipment checked in the daily inspection.

5-year plan

The goal of the 5-year plan is to grasp the actual costs needed by specifically sorting out repairs and investment. "Specifically sorting out" means that repairs and renewals are to be sorted out based on the 30-year plan, inspection-based judgment, and assumed actual work.

As mentioned above, comprehensive discussions and adjustments must be made between the department in charge of the budget and the department that requests the budget in order to create a feasible business plan.

The 5-year plan provides information on what businesses are specifically scheduled during the said period, as well as the required order of preference. Therefore, the 5-year plan becomes a guide for obtaining a clear view of the management situation, not only for the departments requesting budgets but also for all employees, including those in management. In the 5-year plan, the portion that covers the coming year becomes the plan for the next year.

The 30-year plan and 5-year plan should desirably be revised annually. In particular, the 5-year plan must be revised annually.

Although the maintenance plan is a reference that indicates maintenance work to be carried out during the relevant fiscal year, it is not possible to bring maintenance work into effect according to this plan alone. In order to implement the work without delay, we must divide the business into detailed maintenance work schedules, and decide specifically who does what and when. Every maintenance staff member must share the information regarding this situation. Therefore, it is necessary to further divide scheduled maintenance work in an annual plan into monthly and daily plans.

Changes in actual maintenance work normally occur because we sometimes need to urgently address the sites that are affected by climate and natural conditions. Changes in the maintenance plan also occur when the scheduled work is not finished on time due to utilization of inexperienced workers. As seen in the above, the work plan is normally repeatedly revised due to various factors.

When implementing maintenance, we need the daily plan that allocates the day's work to each shift based on the monthly plan. The daily plan tells the maintenance staff what they are supposed to do in the day's shift. It also ensures a complete hand-off between the shifts in order to prevent any oversight.

Every maintenance task carried out during each shift during the day is recorded in the daily plan. These records are very important information for formulating future plans. Namely we can formulate feasible plans only by analyzing and grasping these records. These records also provide effective information for developing a human resource cultivation plan and an employment plan. Thus, we must accumulate this information and analyze them on a daily basis.

6.2.2 Annual Maintenance Plan

6.2.2.1 Basis for Developing Annual Maintenance Plan

- 5-year plan
- Results of annual maintenance plan implemented in the previous year
- The equipment and machinery data necessary for maintenance and change-related rules that have been accumulated in the past maintenance.
- Results of track inspections
- Regulations on track maintenance work and related regulations
- Resources (personnel, machinery and equipment) held by the company

6.2.2.2 Requirements for Developing Annual Maintenance Plan

- It is necessary to consider developing an annual maintenance plan in consideration of workload to be carried out and supply of budget, personnel and materials held by the company.
- Should a new maintenance task arise from the results of track inspections, the annual maintenance plan should be appropriately modified.
- When developing an annual maintenance plan, it is necessary to equalize monthly maintenance tasks.

6.2.3 Monthly Maintenance Plan

6.2.3.1 Basis for Developing Monthly Maintenance Plan

- Annual maintenance plan approved by the company
- Results of track inspections
- Results of monthly maintenance plan implemented in the previous month
- Regulations on track maintenance work and related regulations
- Resources (personnel, machinery and equipment) held by the company

6.2.3.2 Requirements for Developing Monthly Maintenance Plan

- It is necessary to consider developing a monthly maintenance plan in consideration of workload to be carried out and supply of personnel and materials held by the company.
- Should a new maintenance task arise from the results of track inspections, the monthly maintenance plan should be appropriately modified.

6.2.4 Daily Maintenance Plan

Daily maintenance plan forms the basis to complete a monthly maintenance plan. Therefore, it is necessary to specifically organize a daily task, to define work items, and to establish the goal of their work.

6.2.4.1 Basis for Developing Daily Maintenance Plan

- Monthly maintenance plan
- Results of track inspections
- Results of the plan for the preceding shift (in the 3-shift per 1-day system. Each shift engages in the development of a daily maintenance plan.)
- Resources (personnel, machinery and equipment) held by the company
- Weather

6.2.4.2 Requirements for the development of the day's maintenance plan

- Tasks in day's maintenance plan comply with those tasks in monthly maintenance plan.
- Should a new maintenance task arise from the results of track inspections, the day's maintenance plan should be appropriately modified.

6.3 Regulations on Implementation of Track Maintenance

6.3.1 Basic Track Maintenance Tasks

- Rail renewal
- Rail grinding
- Lubrication to top surfaces of curved rails
- Fastening system renewal
- Sleeper renewal
- Tamping after adjustments of four parameters (gauge, cross level, alignment, and longitudinal level)

The details on these track maintenance tasks are defined in the track maintenance manual.

6.3.2 Requirements for Track Maintenance

6.3.2.1 Requirements for Preliminary Step to Implement Track Maintenance

- Daily maintenance plan
- Personnel and machines for performing repair work defined in a daily maintenance plan
- Personnel who perform any maintenance or repair work must fully understand the requirements for safety and quality of repair work.
- Personnel who uses machines is responsible for keeping them in good condition.
- Dispatching materials are to be registered with a material manager by filling out a ledger.
- Implement the appropriate registration process for confirmation according to the regulations. For repair, contact relevant authorities and ask them for their cooperation.
- For repair work, security personnel must be positioned as appropriate to perform the work safely.

6.3.2.2 Requirements for Implementation Phase of Track Maintenance

- Perform repair work according to the guidance received from the unit chief and according to the regulations.
- For repair work, security personnel must be positioned as appropriate to perform the work safely.

- Personnel who perform repair work ensure quality and workplace safety by observing applicable laws and regulations and by following prescribed steps.

6.3.2.3 Requirements for Completion Phase of Track Maintenance

- After track maintenance is completed, the track must be inspected to make sure that safe and stable urban railway operations are able to be carried out on and after the following day.
- According to the regulations, put the sign markers for ensuring safety back into place.
- Adjust machines and put materials in order before returning them to the warehouse. Arrange them neatly in position.
- Based on the amount of work completed, count the materials used and workers and record the completion status of day's maintenance plan.
- Make an analysis of and calculate the day’s safety, condition of quality and work efficiency, and then enter comments.
- Based on the results of an investigation into practices, develop a maintenance plan for the following day.

7. Regulations on Document Retention Period (to be added later)

8. Forms and Appendices

Common Inspection Record Form

Between stations	Line name	A line/ B line	Kilometrage (Km)	Left rail/ Right rail	Inner rail/ Outer rail	Inspection result		Quantity	Unit	Remark
						Contents of inspection	State			

Four-item Measurement Record Form (parameters are to be measured every 5 meters)

Between stations	Line name	A line/ B line	Kilometrage (Km)	Left rail/ Right rail	Gauge			Cross level			Alignment			Longitudinal level			Twist			Remark
					TK	TT	CL	TK	TT	CL	TK	TT	CL	TK	TT	CL	TK	TT	CL	

TK: Design value; TT: Measured value; CL: Magnitude of irregularity

Document Containing Characteristics of Railway Line

Order	**Design element of railway line**	
1	Kilometrage	
2	2D plan	
3	Longitudinal gradient	
4	Type of roadbed	
5	Locations of joints and fastening system	

Rail Head Wear Inspection Record Form

Between stations	Line name	Date of manufacture	Kilometrage	Straight line/ Curved line	Track Type	Date of laying of rails	Monitored wearing depth of top surface of rail							
							1st year	2nd year	3rd year	4th year	5th year	6th year	7th year	8th year
							Depth of wear	Depth of wear	Depth of wear	Depth of wear	Depth of wear	Depth of wear	Depth of wear	Depth of wear
							Passed tonnage	Passed tonnage	Passed tonnage	Passed tonnage	Passed tonnage	Passed tonnage	Passed tonnage	Passed tonnage

Rail Damage Record Forms

Date failure occurred	Between stations	A line/B line	Kilometrage	Curve radius	Inner/outer rails	Type of crack

Date rail was laid	Passed tonnage	Type of rail			Manufacturer	Date of manufacture
		New product Recycled product	50kg 60kg	Ordinary rail Heat-processed rail		

Ballast track bed	Type of fastening system	Type of joint	Joint clearance between rails (mm)	Longitudinal level at joint (mm)	Rail wear depth	Remark
					Top surface… mm Running surface… mm	

Description of processing method……………………………………………
Replacement timing

Rail Surface Damage Record Form

Inspection date	Monitored defects on rail surfaces (history)	Description concerning progress of damage
Date	*Addition of vertical projection view of rail*	
Date	*Addition of vertical projection view of rail*	
Date	*Addition of vertical projection view of rail*	

Damage Described on Rail Bottom Record Form

Inspection date	Monitoring of state of damages to rail surface (History)	Description concerning progress of damage
Date	*Addition of the end view of the rail bottom*	
Date	*Addition of the end view of the rail bottom*	
Date	*Addition of the end view of the rail bottom*	

Turnout and Crossing Wear Inspection Record Form

Inspection date	Date of laying of rails	Tongue rail	Crossing	Guard rail	Lead rail	Stock rail	Running rail	Remark

Appendix8-6-7-1-B(CTC)

Turnout and Crossing Damage Record Form (for a mechanical installation other than for turnouts and crossings, results are to be recorded on the Rail Inspection Form)

Date failure occurred	Site of occurrence	Turnout and crossing number	Type of turnout and crossing	Type of track bed

Date of laying of rails	Passed tonnage	Manufacturer	Date of manufacture

Name of finder		Commendation
Repair procedure		Remark
Repair timing		Remark

Inspection date	**Changes in the failed portion over time**
1st time…………………………….	*No description*
2nd time…………………………….	*First description*
3rd time…………………………….	*Description of each of the previous times.*
4th time…………………………….	*Description of each of the previous times.*
5th time…………………………….	*Description of each of the previous times.*
6th time…………………………….	*Description of each of the previous times.*

Four-item Measurement at Turnout and Crossing Record Form

Inspection date	Gauge			Cross level			Alignment			Longitudinal level			Check gauge		Difference between tongue rail and stock rail	Clearance between tongue rail and stock rail	
	1	…	10	1	…	10	2’	5’	6’	2’	5’	11’	11	12			
																	Design value
																	Measured value
																	Difference between measured and design values
																	Difference between before and after repair
																	Design value
																	On-site measurement
																	Difference between measured and design values
																	Difference between before and after repair

Tongue Rail Heel and Crossing Toe Joint Clearance Measurement Recording Form

Between stations	Line name	Kilometrage (km)	Measurement of tongue rail heel			Measurement of crossing toe			Remark
			Design value	Left side	Right side	Design value	Left side	Right side	

Rail Joint Inspection Record Form

Inspection date	Between stations	A line/ B line	Kilometrage	Type of rail	Type of track bed	Longitudinal level of joints (Yes/No)	Defect on rail surface (Yes/No)	Deviation of longitudinal level at the top surface of rail	Rail misalignment at joint	Remark

Rail Joint Parts Inspection Record Form

Inspection date	Between stations	A line/ B line	Kilometrage	Inner rail/ Outer rail	Type of track bed	Contents of inspection			
						Type of joint bar and bolt	Description	Description of status	Remark

Damage on Joint Bar Record Form

Inspection date	Between stations	A line/ B line	Kilometrage	Straight line/Curved line R =	Left/Right	Inner/Outer	Type of track bed	Type of crack	Outline drawing	Remark
									Image of joint bar added	
									Image of joint bar added	

Expansion Joint Inspection Record Form

Inspection date	Gauge			Cross level			Alignment	Longitudinal level	Travel distance				Remark
									Left rail		Right rail		
	1	2	3	1	2	3	2	2	Tongue rail	Stock rail	Tongue rail	Stock rail	

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Civil Structure Maintenance Manual

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Chapter 1: Legal Foundation and Reference Materials

1.1 Legal Foundation

- National Law on Civil Engineering Work No. 50/2014/QH13 dated 2014/6/18
- Decree No. 114/2010/NĐ-CP on Maintenance of Civil Structure dated 2010/12/06
- Traffic and Transportation Ministry Circular No. 20/2013/TT-BGVTV on Management and Maintenance of Railway Structures dated 2015/08/16
- Decree No. 46/2015/NĐ-CP on Quality Control of Civil Structure dated 2015/05/12
- Decree No. 32/2015/NĐ-CP on Management of Construction Investment Costs dated 2015/03/25
- Labor Law by Diet No. 10/2012/QH13 dated 2012/06/18

1.2 Reference Materials

- Documents and materials from 2A Line work
- Basic Standard No. TCCS 01: 2010/VNRA on Maintenance Procure of Railway Bridges and Tunnels
- Our experience gained from maintaining civil structures at Tokyo Metro

Chapter 2: Types of Maintenance

Urban railways must continue to function efficiently without unexpected delays or problems. However, equipment inevitably deteriorates due to repeated use. Therefore, urban railway maintenance staff must check equipment on a daily basis and repair any deteriorated sections that are found on a timely basis so that urban railway operation will not be affected.

We must abandon the idea of repairing an object after it breaks. If we find a deteriorated section, we must repair it before it causes an entire structure to collapse, thereby forcing us to stop operations.

2.1 List of Structures That Require Maintenance

Check and confirm deterioration of the structure and equipment by comparing them against the design documents.

a. Parts of buildings

Order	Structure and equipment	Inspection frequency/year
1	Wall surfaces	1
2	Ceiling	1
3	Window	1 - 2
4	Roof	1
5	Drainpipe	1
6	Soil tank	3
7	Water-purifier tank	3
8	Pressure tank	1
9	Booster feed tank	1
10	Water receiving tank	1
11	Elevated reservoir	1
12	Hot water supply system	1
13	Gas powered hot water heater	1
14	Automatic door	3
15	Shutter	1
16	Direction board	1
17	Drainpipe	1
18	Garden tree	2
19	Disaster control equipment	
20	Automatic fire alarm	1

21	Fire extinguishing equipment	1
22	Operator for smoke exhaust and ventilation	0.5
23	Water bar	1
24	Lightning rod	1
25	Decorative sheet	2

b. List of fire extinguishing equipment (Inspection according to Vietnam's fire protection regulations)

Automatic fire alarm	Fire extinguishing equipment
- Automatic fire alarm	- Fire hydrant, water intake and nozzle
- Heat detector	- Water tube system to supply water to extinguish fires
- Smoke detector	- Fire pump (Diesel powered)
- Sprinkler	- Hydrant valve
- Fire alarm	- Fire hose (water is put in)
	- Emergency lamp, fire lamp, accident alarm lamp and indicators for fire-fighting equipment

c. Portion of civil structure

Viaducts	- Milestone - Beam and related parts - Beam joint and telescopic joint - Bridge face and related parts - Bearing - Abutment, landing pier, hand rail, soundproof wall, etc.
Tunnel	- Tunnel lining - Telescopic joint and coupling - Dewatering in and out of tunnel
Soil road bed	- Soil road surface - Welded part of bridge and road

2.2 Types of Maintenance

Maintenance of urban railway equipment is divided into repairs and upgrading.

+ Repairs (Implementation on a daily basis)

Repairs denotes restoration of deteriorated portions based on inspection results. Although repair costs are increasing each year, annual repair costs should be equalized.

+ Upgrade

Upgrading denotes replacing an existing item of equipment with a new one, or adding a new item of equipment to an existing one when it is not possible to completely recover its functionality by repeated repairs alone.

Large category	Middle category	Small category	Repair	Upgrade
Station	Platform	Roof	- Repair of a hole in a roof - Repair of a corroded pillar supporting a roof	- Replacement of an entire roof
		Platform surface	- Repair of a broken tile on the surface	- Replacement of all tiles on the surface
	Staircase	Surface of footsteps	- Repair of a broken surface of a footstep	- Replacement of entire surface of a footstep
		Handrail of staircase	- Repair of a broken handrail	- Replacement of every handrail of a footstep
	Station compartments	Door	- Repair of a broken door	- Replacement of every door
		Window	- Repair of broken window glass - Repair of a broken sash	- Replacement of broken window glass - Replacement of a broken sash
		Wall	- Repair of a cracked wall	- Refurnish and replace an entire wall
		Ceiling (plaster)	- Repair of a damaged, cracked or peeler plaster jacket	- Replacement of ceiling system of plaster jacket
Building	Living space	Roof	- Repair of a hole in a roof - Repair of a corroded pillar supporting a roof	- Replacement of an entire roof
		Surface of footsteps	- Repair of a broken surface of a footstep	- Replacement of entire surface of a footstep
		Handrail of staircase	- Repairs required	- Replacement of every handrail of a footstep
		Door	- Repairs required	- Replacement of every window
		Window	- Repair of broken window glass - Repair of a broken sash	- Replacement of broken window glass - Replacement of a broken sash

		Wall	- Repair of a cracked wall	- Refurnish and replace an entire wall
	Water supply and water discharge systems	- Water supplying pipe - Water supplying pipe for fire-fighting - Water discharge pipe	- Repairs of water leakages - Repairs required	- Replacement of a water supplying pipe system - Replacement of a water supplying pipe system for fire-fighting - Replacement of a water discharge pipe system
		- Water feed tank - Water feed tank for fire-fighting - Drain tank	- Repairs of water leakages - Cleaning of a water feed tank to improve its level of hygiene	- New construction of a water feed tank, water tank for fire-fighting, or a drain tank
		- Soil water valve	- Repairs of water leakages	- Replacement of an entire valve system
		- Pump for clear water, and pump for fire-fighting	- Repairs required	- Replacement of a pump
Viaducts	Pier		- Repair of large cracks	- Improvement to suppress cracks and rust on reinforcing bars
	Beam		- Repair of large cracks	- Improvement to suppress cracks and rust on reinforcing bars

2.3 Inspection Method

a. Inspection of concrete (Frequently observed failures)

- When inspecting concrete-related cracks, you must accurately check how many cracked portions there are on the viaducts, where they develop, and what causes the cracks to occur. Follow up and record the inspection results, and then develop a maintenance plan with appropriate cycles and methodology.
- Crack size measuring method: Use a measuring scale for the inspection.
  + It is very important to identify the size of cracks, where are they, and conditions of reinforcing bars.
- Cracks are categorized into two types.
  + Dangerous cracks (They develop on bridge pier and beams)

    This refers to cracks larger than X-cross type or nearby cracks, or rusty cracks. Dangerous cracks can be further divided into two additional types.

a. Cracks that require immediate repair
b. Cracks whose repair may be done within two- or three-year time frame

You must propose repairs for identified cracks on a timely basis.

+ Cracks that do not pose a problem when identified

Cracks that are generated as part of the concrete hardening process are not dangerous. These cracks are not a problem at this point. These cracks, however, can become a problem in 10 or 20 years namely over a long-term time frame.

(Cause)

A possible cause may be that the load was heavier than anticipated (Example: A train was longer or heavier than that assumed in the initial design). However, such cases are rare. Alkaline properties of concrete are lost over time.

Since concrete in the initial stage has sufficient alkaline properties, immersion in water does not rust reinforcing bars. However, when concrete loses its alkaline properties, water rusts the reinforcing bars. Rust on reinforcing bars will cause them to expand, which can cause cracks to develop in concrete. At this point, cracks develop not only inside the concrete but also on the concrete surface.

Specifically, the diameter of reinforcing bars shrinks and, as a result, the performance of the structure they are in will be reduced in the following process of falling surface of concrete -> Exposure of reinforcing bars -> Rusting of reinforcing bars due to water.

b. Building and Equipment Inspection

Check and confirm deterioration of the structure and equipment by comparing them against the design documents.

2.4 Defect Judgment Criteria

Class		Structure soundness judgment criteria
A		Existence of an abnormality that threatens the following. - Operational security - Normal train operations - Public safety Or an abnormality that potentially threatens to compromise the above.
	AA	Existence of an abnormality that threatens the following. - Operational security - Normal train operations

		- Public safety - An abnormality that requires emergency measures Repair period: Train must be stopped immediately.
	A1	- An ongoing abnormality is deteriorating the performance of a structure. - Structural performance can be completely lost due to heavy rains or flooding. Repair period: Must be repaired immediately during the night of the day it occurred.
	A2	- An existing abnormality threatens to deteriorate performance of a structure in the future. Repair period: Within a year from the day of inspection
B		- Existence of an abnormality that threatens to grow to soundness A in the future.
C		- A portion of a structure that has a slight abnormality.
S		- Sound portion of a structure

Chapter 3 Maintenance Facilities

- Inspection tools
  + Flashlight
  + Binoculars
  + Inspection hammers, etc.
- High-elevation work
  + Ladder
  + Vehicle for high-elevation work
- Materials in storage
  + You must repair urban railway equipment at the appropriate timing. "Appropriate timing" as used herein may be the moment you detect the deteriorated portion or after the last train of the day. Or it can be a month or six months later. The basic premise in selecting an "appropriate timing" for repair is that it does not stop our business operations. In addition, compatibility with Workload Planning is also an important factor in deciding the timing. You should not choose a timing when the materials necessary for repair are out of stock or unavailable.
  + Therefore, you must keep a certain volume of materials necessary for repairs in storage. The railway business operator himself must decide at their own risk the materials and respective quantities to be stored. Over time from the launch of business operations, deteriorating portions change on a constant basis. Despite ongoing daily inspections and repair, the number of deteriorated portions will inevitably increase over time. Therefore, you must reexamine the materials and respective quantities to be stored once a year.

+ A monthly stock-take is also necessary. You should determine the quantities of the stored materials referencing the following three types as a guideline.
  a. Minimum storage quantities to be maintained
  b. Storage quantities to be maintained at the start of the procurement procedure
  c. Maximum storage quantities to be maintained

Chapter 4: Requirements for Maintenance Staff

- Staff who maintain civil structures must be appropriately educated and possess the necessary knowledge and skills to work on civil structures.
- When concluding an inspection or repair agreement with a subcontractor, maintenance staff shall confirm whether the subcontractor has the necessary capabilities to carry out the said inspections or repairs.
- Capability Requirements for Maintenance Staff (To be updated when upon reception of 2A Line education materials).

Chapter 5: Inspection and Judgment

5.1 Inspection (Inspection unit: 3 people/shift)

a. Appearance inspection of viaducts and tunnels: 3 times/month

- Inspection tools
  + Flashlight
  + Inspection hammers
  + Air whistle
  + Binoculars (As needed)
- Inspection staff assignment
  + Person in charge of inspection [Unit chief]: 1 person, Responsible for inspection results
  + People in charge of inspection [Staff]: 2 people

(Inspection Method)

1) The walking direction of every staff member must be opposite to the direction the train is traveling in.
(Staff members must walk in the direction opposite to the direction the train is traveling in. The range that can be checked by the staff in one observation is half way through an viaducts or

tunnel.)

2) Every staff member must walk at normal walking speed.

3) During the inspection, [Unit chief] and [Staff] must detect defective portions that adversely affect train movement.

4) [Unit chief] must responsibly judge such portions as defective according to the Defect Judgment Criteria, and also decide their repair timing.

5) If suspicions remain about a location that has already been inspected, [Unit chief] and [Staff] shall check it again by getting closer to it using a ladder or other tool for high-elevation work. Alternatively, they must observe conditions of the suspected portion while the train is traveling.

6) When a portion with a very serious defect is detected, [Unit chief] in charge shall issue an instruction to stop the train immediately.

7) Since the inspection will take place during the normal train operation time period, one inspection [Staff member] must carefully be on the lookout for approaching trains. This staff member must walk 20 to 40 m ahead of [Unit chief] and other [Staff] because he is responsible for identifying any approaching trains.

8) If a train is approaching, this staff member must notify [Unit chief] and [Staff] of it using an air whistle.

When the air whistle is heard, [Unit chief] and [Staff] must stop the inspection temporarily.

9) [Staff] shall describe information relevant to defective portions in detail on the Inspection Record. (Photos shall be taken as needed.)

b. Appearance inspection of viaducts and tunnels: Once/2 years

- Inspection tools
  + Flashlight
  + Binoculars
  + Inspection hammers
  + Ladder
  + Tools for high-elevation work (as needed)
- Staff assignment
  + Person in charge of inspection [Unit chief]: 1 person, Responsible for inspection results
  + People in charge of inspection [Staff]: 2 people

(Inspection Method)

1) Every staff member must walk at a leisurely pace.

2) [Unit chief] and [Staff] must detect defective portions (cracks, water leakages, exposed reinforcing plates, etc.) that adversely affects train movement.

3) [Unit chief] must responsibly judge such portions as defective according to the Defect Judgment Criteria, and also decide their repair timing.

4) If suspicions remain about an already inspected portion, [Unit chief] and [Staff] shall check it again by getting closer to it using a ladder or other tool for high-elevation work.

5) When a portion with a very serious defect is detected, [Unit chief] in charge shall issue an instruction to stop the train immediately.

6) [Staff] shall describe information relevant to defective portions in detail on the Inspection Record. (Photos shall be taken as needed.)

c. Appearance inspection of tunnels: Once/10 years

- Inspection tools
  + Flashlight
  + Binoculars
  + Inspection hammers
  + Tools for high-elevation work
- Staff assignment
  + Person in charge of inspection [Unit chief]: 1 person, Responsible for inspection results
  + People in charge of inspection [Staff]: 1 person
  + Inspection car [Driver]: 1 person

(Inspection Method)

1) [Unit chief] and [Staff] must detect defective portions (cracks, water leakages, exposed reinforcing plates, etc.) near to a structure that adversely affects train movement.

2) [Unit chief] must responsibly judge such portions as defective according to the Defect Judgment Criteria, and also decide their repair timing.

3) When a portion with a very serious defect is detected, [Unit chief] in charge shall issue an instruction to stop the train immediately.

4) [Staff] shall describe information relevant to defective portions in detail on the Inspection Record. (Photos shall be taken as needed.)

5. When [Unit chief] and [Staff] started the work, [Driver] of the inspection car must stop the tool being used for high-elevation work.

d. Buildings appearance inspection: Once/year

- Inspection tools
  + Flashlight
  + Binoculars

  + Inspection hammers
  + Ladder
  + Tools for high-elevation work (as needed)
- Staff assignment
  + Person in charge of inspection [Unit chief]: 1 person, Responsible for inspection results
  + People in charge of inspection [Staff]: 2 people

(Inspection Method)

1) [Unit chief] and [Staff] must detect defective portions (cracks, water leakage, stains, etc.) that adversely affect the soundness of buildings.
2) [Unit chief] must responsibly judge such portions as defective according to the Defect Judgment Criteria, and also decide their repair timing.
3) If suspicions remain about an already inspected portion, [Unit chief] and [Staff] shall check it again by getting closer to it using a ladder or other tool for high-elevation work.
4) When a portion with a very serious defect is detected, [Unit chief] in charge shall issue an instruction to stop using the building.
5) [Staff] shall describe information relevant to defective portions in detail on the Inspection Record. (Photos shall be taken as needed.)

e. Inspection of building's equipment function: 1 to 3 times/year

- Inspection tools
  + Inspection tools appropriate for the target equipment must be used.
- Staff assignment
  + Person in charge of inspection [Unit chief]: 1 person, Responsible for inspection results
  + People in charge of inspection [Staff]: 2

(Inspection Method)

1) [Unit chief] and [Staff] shall inspect whether each item of equipment meets the specified function criteria.
2) [Unit chief] must responsibly judge such portions as defective according to the Defect Judgment Criteria, and also decide their repair timing.
3) When a portion with a very serious defect is detected, [Unit chief] in charge shall issue an instruction to stop using the equipment.
4) [Staff] shall describe information relevant to defective portions in detail on the Inspection Record. (Photos shall be taken as needed.)

f. Inspection of building's equipment materials: 1 to 3 times/year

Inspection of outside of building and station (Walls, windows, roofs, water pipes, lightning protection system, etc.)

- Inspection tools
  + Binoculars
  + Inspection tools appropriate for the target equipment must be used.
  + Ladder and tools for high-elevation work (as needed)

(Inspection Method)

1) [Unit chief] and [Staff] must detect defective portions (cracks, water leakages, etc.) that adversely affect use of the building.
   - Door: Check it for cracks and breakages. Staff members must make sure there are no problems opening and closing the door.
   - Water pipe system: Staff members must check whether the system operates normally when a faucet is opened. They must also check the system for water leaks and flooding of the lower levels.
   - Staff members must make sure that disaster-prevention signs and regulation indication boards are set in the specified positions.
   - The staff member makes sure that evacuees can get to the basement via the emergency stairs.
   - The staff member checks that the fire-fighting system equipment operate as specified.
   - Electric pump, diesel pump, water supply system for firefighting, automatic fire alarm system (smoke and temperature detection tools, sprinklers, etc.)
   - The staff member checks that the exhaust and ventilation systems operate as specified.
   - Lightning protection system: Lightning rod, grounding wires, earth resistance measurement system, etc. are checked to ensure they are operating normally.
2) [Unit chief] must responsibly judge such portions as defective according to the Defect Judgment Criteria, and also decide their repair timing.
3) If suspicions remain about an already inspected portion, [Unit chief] and [Staff] shall check it again by getting closer to it using a ladder or other tool for high-elevation work.
4) When a portion with a very serious defect is detected, [Unit chief] in charge shall issue an instruction to stop using the equipment or structure. When the equipment or structure can affect safe travel of the train, [Unit chief] shall issue an instruction to stop the train immediately.
5) [Staff] shall describe information relevant to defective portions in detail on the Inspection Record. (Photos shall be taken as needed.)

Inspection of inside of structures and stations (Wall, ceiling, lighting system, entrance door, water supply and drainage system, fire protection sign, emergency guidance lamp, water stop door, etc.)

- Inspection tools
  + Inspection tools suited for each type of equipment must be used.
  + Ladder and tools for high-elevation work (as needed)

(Inspection Method)

1) [Unit chief] and [Staff] must detect defective portions (cracks, penetration of water, water leakages, etc.) that affect use and soundness of the building.
2) [Unit chief] must responsibly judge such portions as defective according to the Defect Judgment Criteria, and also decide their repair timing.
3) If suspicions remain about an already inspected portion, [Unit chief] and [Staff] shall check it again by getting closer to it using a ladder or other tool for high-elevation work.
4) When a portion with a very serious defect is detected, [Unit chief] in charge shall issue an instruction to stop using the equipment.
5) [Staff] shall describe information relevant to defective portions in detail on the Inspection Record. (Photos shall be taken as needed.)

5.2 Treatment of failure and Accident

This item describes responses to be taken to accidents and failures, responsibility sharing up to recovery, and utilization of accident and failure information.

a. Responsibility sharing up to recovery

Urban railway equipment must be maintained in such a way that its high-density operation may be continued in good condition without delay. Its operation must be protected to prevent cancellations occurring due to unexpected reasons. However, the equipment inevitably deteriorates due to repeated use, and will fail if we miss carrying out timely repairs. In addition, other types of accidents may occur including a car colliding against pier of viaducts, and accidental contact between a moving train and a person that are not attributable to the train company.

Urban railway operations are forced to stop if an accident or failure occurs. In order to resume operations at an earliest possible timing, the train company must make the necessary preparations on a daily basis to recover from accidents and failures. Preparation for accidents and failures involves making clear who engages in what type of recovery work and with what level of responsibility. Generally speaking, the organizations involved in field work are responsible for recovery steps. They must designate a person responsible and workers in advance in order to make decisions necessary for the recovery including selection of the recovery work method and check of results of recovery efforts.

The above-mentioned preparation includes designating in advance a department for central control of the information, and forming of a consensus on retention of materials necessary for recovery steps in order to avoid delays in the recovery work due to mixed intelligence upon the occurrence of an accident or failure.

b. Utilization of information on accidents and failures

We must utilize the information about accidents and failures that have occurred in order to prevent recurrence of similar problems. There are two approaches to utilizing such information.

The first is to share the intelligence, which is obtained from a thorough investigation of causes, immediately among the organizations involved in field work, and start an emergency check for signs of occurrence of similar accidents or failures. In this way, we can not only prevent occurrence of similar accidents or failures but also help ensure the people in the organizations involved in field work have the same level of awareness regarding the work. This is a very effective approach when the HQ organization is aiming to standardize maintenance quality levels.

Secondly, accumulating accident and failure information provides the chance for us to recognize the necessity of reviewing daily maintenance methods, and also the chance to identify the type of information to be reflected in the design when upgrading an item of equipment. Analysis of the accumulated accident and failure information clearly visualizes the meaning of individual information that might have been overlooked in response to a single accident or failure. Such information presents us, for instance, the fact that a specific part deteriorates more frequently than others, and equipment deterioration becomes more evident depending on the number of years that have passed since its introduction. The above information is also an effective means of preventing recurrence of similar accidents and failures.

Therefore, we must utilize the accident and failure information after recovery, too, without discarding them. In general, the HQ organization gathers, store and analyze them.

(Response Procedure at Occurrence of an Accident/Failure)

If an accident/failure occurred, OU shall check the side immediately.

- OU Manager
  + Upon receiving the report, OU Manager shall visit the site to check the situation.
  + The Manager shall designate a person responsible for inspection work and a person responsible for repair work (of the day).
  + The Manager shall designate a liaison with OCC.
  + The Manager shall review the reports from the person responsible for inspection work and the person responsible for repair work to determine acceptability of the reports.
  + The Manager shall notify the liaison with OCC of the approved matters.

- Person responsible for inspection work
  + This person makes a judgment at the accident site whether continuous safe train operations can be ensured (whether immediate repairs are needed).
  + When immediate repairs are needed, he must present an appropriate repair method (a method that ensures work can be carried out safely in the shortest time in order to reduce adverse effects on passengers).
- Person responsible for repair work
  + He shall be responsible for everything necessary for repair work including materials and staff.
  + After repairs are completed, he shall check safety. He approves resumption of operations when there are no safety-related problems.
    (At first, a test run is carried out at reduced speed in order to make sure there are no problems with the repaired portion. If it is not clear whether any problems still exist, he should not permit train operations to resume.)
- Liaison with OCC
  + He shall immediately report to OCC on the situation of accident/failure (including photos), state of repairs, and security verification.
  + OU shall report to HQ on the accident/failure.
    (The report shall be made on the following day at the latest. If the report cannot be made within the above-mentioned time frame, OU shall confer with HQ regarding a due date for the report.
- The report from OU to HQ shall contain the following information.
  + Detailed accident/failure states
  + Inspection record of the accident/failure site
  + Analysis of cause of the accident/failure
  + Measures to prevent the accident/failure

- HQ
  + HQ checks whether OU's report is sufficient, and if so, approves it.
  + HQ provides the information to other lines to prevent similar accidents/failures from occurring through information sharing.
  + HQ shall conduct internal inspection.
    - HQ checks that the periodic inspection is implemented correctly and completely.
    - HQ checks that the maintenance is implemented correctly on a timely basis.
    - HQ checks that training of OU staff is fully implemented (grasp of the regulations and manuals of OU).

- Preparation for response on a daily basis is important to help ensure a guaranteed response to detected accidents/failures.
  + Training in the case of an accident/failure is necessary (training should be carried out several times a year as a countermeasure against possible accidents/failures).
  + Repair materials must be prepared.
    - Materials should be grouped based on specific purpose of repair, and their quantity should also be specified.
    - These repair materials must be stored separately from those used for ordinary repairs.

Chapter 6: Plan Development

6.1 Business Plan

Businesses, including the railway business and other businesses, usually consist of several different fields. In such a case, each department that runs some aspect of the business requests, at the appropriate time, a budget for repairs/upgrades of equipment in its field of charge in consideration of the timing and contents of the repair/upgrade. This is called a budgetary request.

The department in charge of the budget (generally the financial department) adjusts the budget size from a company-wide standpoint after coordinating the budget request amounts requested by each department. The term adjustment as used here refers to the negotiations between the department in charge of the budget and each department regarding the assuredness of budget request details, reconfirmation of budget size, and timing of the budgetary request to be issued. The adjustment, particularly adjustment of timing, must be done between the department in charge of the budget and the department that submitted the budgetary request on the condition that safe urban railway operations can be assured based on their technical rationales.

A business plan is usually formulated for three different periods: long-term, mid-term and next year.

a. Long-term plan: 30 years

A long-term plan is formulated in such a way that enormous upgrade costs may be equalized over the entire business without threatening safe urban railway operations. In the process of formulation, we can understand the trends in the repair and upgrade costs for the entire business. We must also prepare a long-running employment policy based on the long-term plan.

Every item of urban railway equipment must eventually be replaced. If, however, replacement of a large number of items of equipment is required at the same time, we must prepare an enormous amount of funds. Therefore, in addition to the size of annual repair costs, we must coordinate and clearly describe the size of investment costs for equipment upgrades in the long-term plan based on the durable years of each item of equipment being set during the design phase, and the current state of the equipment checked in the daily inspection.

- The long-term maintenance plan (30 years) shall be developed based on the maintenance plan developed in the initial year of establishment of the business.
  + HQ: HQ functions as the investigation and planning organization of the long-term plan.
  + OU: It is the organization that implements the plan and delivers the results.
- We must verify four points before developing the long-term plan.
  1. Estimating breakage-related conditions.
  2. Identifying how fast broken portions can be fixed based on past records.

3. Investigating how many staff will be required to carry out specific repairs based on past records.
4. Investigating repair costs based on past records.

b. Mid-term plan: 5 years

Its goal is to grasp the actual costs needed for investment by making aspects concerning repairs and investment more manageable. Making things clear means to organize aspects related to repairs and upgrades based on the long-term plan, inspection-based judgments, and assumed actual work. As mentioned above, comprehensive discussions and adjustments must be made between the department in charge of the budget and the department that requests the budget in order to create a feasible mid-term business plan.

The long-term plan and the mid-term plan should desirably be revised each year. The mid-term plan provides information on what businesses are specifically scheduled during the said period, as well as the required order of preference. In the mid-term plan, the portion that is related to the coming year becomes the next year plan.

- The five years maintenance plan is formulated based on the inspection plan and the business plan formulated during the business' first year of operation.
  + This plan is updated once a year.
    (Example: Five-year plan covers the period of 2013 to 2018. When it is updated in the next year, the five-year plan covers the period from 2014 to 2019.)
- The mid-term plan shall contain the following items.
  + Period (from when to when)
  + Classification of businesses
  + Budget
  + Business No., name of the person who created the plan
  + Place of work
  + Purpose of the work
  + Description of the work implemented
  + Requirements to be met (machines, human resources, electricity and water)
  + List of items for which difficulties are anticipated during the work
  + Relevant departments whose cooperation is solicited for the work

c. Annual plan

Although the annual plan describes the work to be implemented during the said year, it is not possible to actually execute the work according to this plan alone. In order to implement the work without delay, we must divide the business into detailed maintenance work schedules, and decide specifically who does what and when. Accordingly, all maintenance staff members must share the information regarding this situation. Therefore, usually two types of Workload Planning are created. One is the annual plan that allocates the work to each month, and the other is the monthly plan that allocates staff members to each task and sets down the working days.

When implementing maintenance, we need the daily plan that allocates the daily work to each shift based on the monthly plan. The daily plan tells the maintenance staff what they are supposed to do in the day's shift. It also ensures a complete hand-off between the shifts in order to prevent any oversight.

Every maintenance task carried out during each shift during the day is recorded in the daily plan. These records are very important information for formulating future plans. These records also provide effective information for developing a human resource cultivation plan and an employment plan. Thus, we must accumulate this information and analyze them on a daily basis.

Changes in the workload plan normally occur when maintenance work is actually being carried out because we sometimes need to urgently address the sites that are affected by climate and natural conditions. Changes in the workload plan also occur when the scheduled work is not finished in time due to utilization of inexperienced workers.

6.2 Human Resource Cultivation Plan

The number of staff calculated in the above is the minimum required to carry out the business in the initial phase of operations. In order to prevent our business operations from being interrupted due to staff resignations, holidays and age-limit retirement of employees as well as time-dependent workloads, we must have an employment and cultivation plan.

We need to establish an education system that includes classroom lectures and practical training in order to help new employees clearly understand their assignments because their level of experience and knowledge were not uniform when they joined the company. Maintenance plan varies over time, so contents of the education programs must be periodically updated, too.

(Human Resource Cultivation)

a. The purpose of this is to give the employees a broad understanding of the job in their charge and power to carry it out.

<u>Knowledge</u>

- Every inspection and repair job
- To acquire a good understanding of what they have been instructed to do by the unit chief

<u>Experience</u>

- To perform every inspection and repair job
- Capable of selecting the most appropriate approach in case of emergency

Skill in issuing instructions and education

- To teach know-how and knowledge for inspections and repairs.

b. Job requirements

In order to process the inspection and repair jobs smoothly:

- Employees of OU (in charge of repairs) must have experience and knowledge regarding inspections.
- Employees of OU (in charge of inspection) must have experience and knowledge regarding repairs.

c. Cultivation type

Class for new employees

- Target
  + New employees
- Purpose
  + To acquire basic knowledge required by OU employees at the given duty position.
- Instruction method
  + Classroom lectures
- Contents
  + Understanding of the Civil Structure Maintenance Manual and relevant regulations.
  + Understanding of the theories related to maintenance methods in each specific job.
- Appraisal
  + Test of knowledge acquired the above education.
  + Assessment by unit chief

Class for employees

- Target
  + All employees (except unit chiefs)
- Purpose
  + To ensure smooth execution of assignments by OU employees.
- Instruction method
  + Direct teaching on site.
- Contents
  + Development of technical knowledge.
  + To experience maintenance work in different environments.
- Appraisal

+ Summarized appraisal
+ Assessment by unit chief

6.3 Plan Development Procedure

Based on a review of the data provided by respective sections of OU, the sections at HQ formulate the long-term plan and the detailed plan according to the following table.

HQ	In charge of inspection (1)	In charge of planning (2)	In charge of repairs (3)	In charge of technology (4)
OU	In charge of inspection (5)	In charge of planning (6)	In charge of repairs (7)	

Assignment name	OU	HQ
Estimate of defects	In charge of inspection (5)	In charge of technology (4)
Survey of number of workers and costs	In charge of planning (6)	In charge of planning (2)
Repair speed	In charge of planning (6)	In charge of planning (2)

a. Update of Long-term Plan

The section in charge of planning at HQ is responsible for updating the long-term plan based on the data provided by the section in charge of planning at OU and the section in charge of technology at HQ.

Section in charge of planning (6) [OU] -> Section in charge of planning (2) [HQ] <- Section in charge of planning (4) [HQ]

b. Development of Annual and Monthly maintenance plans based on inspection results

- Preparation of Annual plan and Monthly maintenance plan
  + [Section in charge of planning]: Responsible for formulating the maintenance plan.
  + ([Section in charge of planning] updates the day's plan to formulate the next monthly plan by

the end of this month.

- Formulation Daily maintenance plan
  + [Unit chief] is responsible for formulating the day's maintenance plan.
  + [Unit chief] shall formulate the day's maintenance plan in consideration of the monthly plan and the matters handed to him from the preceding shift or shift of the previous day.
  + He shall previously check the portions that require inspection or repair. As needed, he shall contact the section in charge of planning to the have common understanding on the above.
- Annual maintenance plan development method
  1) [Section in charge of planning] shall review the documents of up to the last inspection. (Judgment, repair period, etc.)
  2) If any question arises about a document, [Section in charge of planning] shall consult with [Unit chief] until a common understanding is reached. As needed, [Section in charge of planning] may request [Unit chief] to re-inspect the matter.
  3) [Section in charge of planning] may formulate the maintenance plan ahead of the repair commitments described in the inspection result.
  4) [Section in charge of planning] must decide the repair method for a defective portion.
  5) When [Section in charge of planning] is unable to decide the repair method, the section may employ a specialized consultant to carry out research and design.
  6) [Section in charge of planning] must prepare repair budgets on a defective portion basis.
  7) [Section in charge of planning] shall formulate the repair plan in accordance with the above procedures.

Chapter 7: Implementing Organization

7.1 Maintenance Staff

- Work shift: 3 shifts

  1st shift: 6:00 start - 15:00 end

  2nd shift: 14:00 start - 23:00 end

  3rd shift: 22:00 start - 7:00 end

  + Workers work 8 hours in each shift. A 1-hour break period is included in the above. (This one hour shall not be included in the duty period of 8 hours.)
  + One hour overlaps between the preceding and succeeding shifts. Hand-off of the work shall be completed within this hour.
  + The number of working hours per week is 40 to 48 hours.

Shift	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
1	A	D	C	B	A	D	C
2	B	A	D	C	B	A	D
3	C	B	A	D	C	B	A

(Number of staff)

Group	Inspection unit	Repair unit
A	3 people	4 people
B	3 people	4 people
C	3 people	4 people
D	3 people	4 people

- Observation of staff during normal inspection: Visual inspection on foot. A lamp is used by the night shift.

The person responsible for the inspection results [Unit chief]	1 person

Person in charge of inspection [Staff]	2 people

An elevating service vehicle is used for inspection of a suspected portion.

- The number of staff members required when a service vehicle for high-elevation work is used

The person responsible for the inspection results [Unit chief]	1 person
Person in charge of inspection [Staff]	1 person
Worker to drive service vehicle used for high-elevation work, operation of the elevating platform and control of lighting	1 person

- Repair staff

The person responsible for safety [Unit chief]	1 person
Person in charge of repairs [Staff]	2 people
Worker to drive service vehicle used for high-elevation work [Staff]	1 person

- Staff to formulate the maintenance plan

In charge of planning	2 people

7.2 Repair Method (Defects that tend to occur)

This section introduces a typical repair method for viaductss and open-cut tunnels. There is a wide range of variations in the target of repair and, on the other hand, repair technology progresses day by day. Thus, we must study the cause of deterioration carefully before choosing an appropriate approach.

a. Viaducts

Falling surface of concrete due to corrosion of reinforcing bars inside reinforced concrete is a deterioration-related phenomenon often observed on viaductss. Falling surface side of the concrete is the portion that does not have to support the generated stress from the design standpoint. Therefore, the repair approach should be selected in consideration of the following.

- A sufficiently alkaline environment must be provided in the periphery of reinforcing bars to prevent any further corrosion.
- Repair materials must be closely adhered to the base material to prevent them from falling again.

Polymer cement mortar is an effective repair material for protecting reinforcing bars since it retains sufficient alkalinity, excels in adhesion to the base material, and also has excellent waterproof properties. Therefore, polymer cement mortar should be used to repair viaductss. When the depth to be repaired by polymer cement mortar is large, it can cure in layers during prolonged repair work. To avoid such problems, a continuous fiber sheet is sometimes inserted between the upper and lower layers. This reduces adhesion between polymer cement mortar layers.

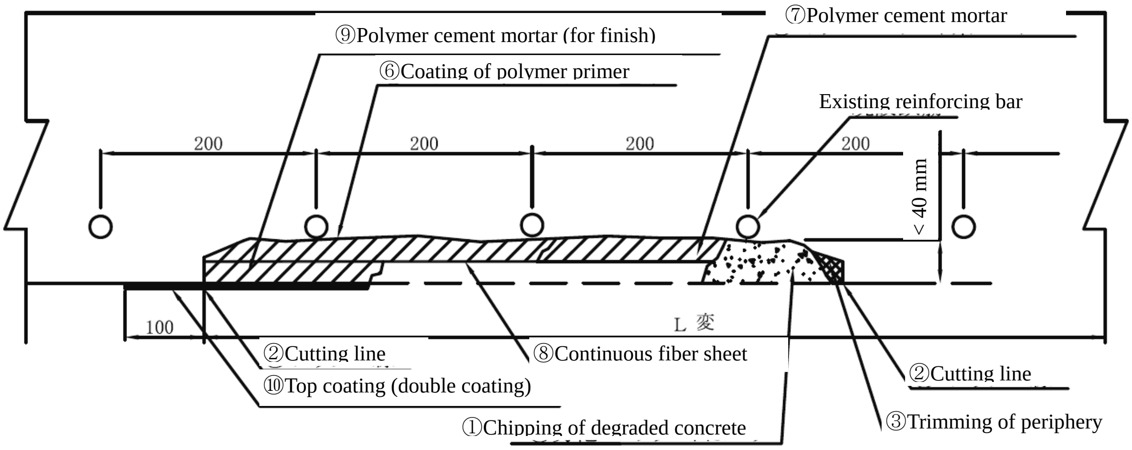


Figure 1: General Drawing of Repair of Elevated Concrete Bridge

b. Open-cut tunnel

Water leakage from the back of a tunnel is a deterioration phenomenon observed in open-cut tunnels. A tunnel is not only constantly exposed to pressure from the ground but it is also subject to water pressure when built below groundwater level. Although a tunnel is designed to sufficiently resist the assumed pressure and great care is paid to its construction, some irregularities resulting from construction work are unavoidable. Then, water with high flow property flows inside the tunnel with water pressure from the locations that are vulnerable to pressure.

Since a tunnel has a reinforced concrete (RC) structure, reinforcing bars must be protected from corrosion as I have previously mentioned repeatedly. Reinforced bars corrode when exposed to water and air. Water leakage in a tunnel creates an environment that corrodes reinforcing bars. Thus, we must eliminate this cause of deterioration. You must choose a repair method in consideration of the following.

- In order to protect reinforcing bars from being exposed to water, we need to inject water-stop materials into cracks positioned below reinforcing bars.
- A sufficiently alkaline environment must be provided in the periphery of reinforcing bars to prevent them from corroding further.

Polymer cement mortar retains sufficient alkalinity, excels in adhesion to the base material, and also has excellent waterproof properties. Thus, after checking that water-stop material is effectively working to stop water, we create a groove using polymer cement mortar to bury the seal material, and add the finishing touch to the water stop effect by using epoxy resin sealing material.

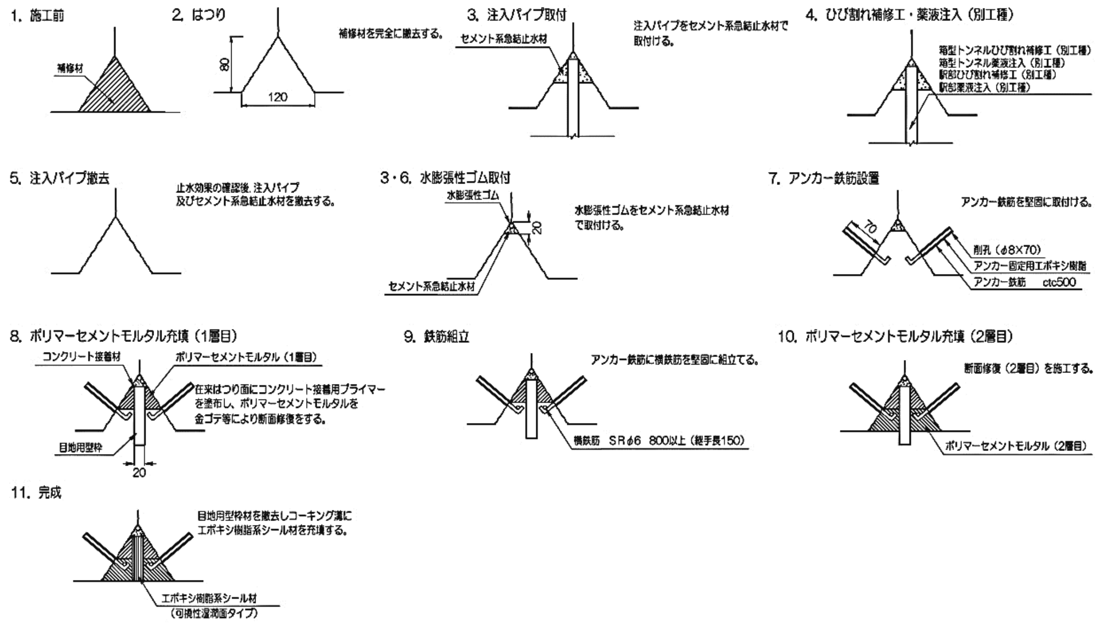


Figure 2: General Drawing of Repair of Open-cut Tunnel

c. Soil road bed

<u>Road bed</u>

1) At the depot, track is in many cases directly installed on the improved ground. The ground in this case is called a soil road bed.

Many abnormalities on the soil road bed are caused by water or consolidation. Therefore, before constructing the track, you should take a range of measures including improving soil properties by forcible water discharge and replacing soil, as well as to increase consolidation pressure by applying a uniform load to the ground for a long period. Despite such measures, abnormalities can occur after operations start. The following three major measures can be taken against such abnormalities.

- Start your visual check from the track on the top surface of the soil road bed. When mud water is spouting out on the ballast bed or any traces of it remain, the soil road bed just below the ballast bed will have in many cases been hollowed out after being turned to sludge by sump water.
- Check the drainage from the previously installed drain trench. If a large volume of water is drained from part of the drain trench when there is no rain, you may suspect in many cases that a huge amount of water has accumulated, or there is sump water in the section between the front and rear drain trenches.
- Or the track is repeatedly sagging at the same position. If sagging continues after the track is repaired, the soil road bed will be hollowed out by sump water or consolidation in many cases.

Such detected abnormalities on the soil road bed require appropriate repairs. I will not mention the repair methods here because they are not unique to railway technology but used as part of general civil engineering work. The only thing you should note in terms of applying the methods to a railway is that it is rather difficult to repair the soil road bed independently. Since the track is laid on the soil road bed, you must scrape out the ballast before starting repairs. Or, sometimes you must remove the track itself before starting repairs. Namely, the Civil Engineering Work Department cannot plan and execute repairs of the soil road on its own. In this case, it is imperative that the Track Department is consulted. When use of the soil road bed is not possible for a prolonged period, consultation with the Rolling Stock Department in the depot will also be necessary to help ensure that train operations are not significantly affected.

When checking earth structures, visual inspection becomes the basis. Check cracks, deformation and flush on the earth structure by visual inspection.

Checks are usually carried out with the naked eye on the track or from the road. However, binoculars are also used when it is not possible to carry out checks with the naked eye due to the distance to the target earth structure.

2) On earth structures that retain the ground with retaining wall made of stones or concrete

If the ground is unstable due to earthquakes or heavy rain, the force acting on an earth structure becomes unbalanced. If the force acting on the earth structure becomes unbalanced, the ground collapses due to downward movement of the soil at a higher position due to gravity. Therefore, in the visual inspection of earth structures, you must detect cracks and spouting of large quantities of water on a daily basis.

Through these inspections, you should not only record detailed information of the accident site but also the conditions under which the earth structure failed. Detailed information on the failed location and the judgment at the point of inspection are important for identifying the target location of repair, and also for grasping the extent of progress prior to the next inspection.

In addition to this information, studying the information concerning the failed part enables us to reflect the recurrence protection measures in the future design.

7.3 Implementation Procedure for Repair Works

a. Removal of peeler concrete (for viaducts and tunnels)

- Tools
  + Inspection hammers
  + Chisel
  + Concrete cutter
  + Chalk for marking
  + Ladder
  + Tools for high-elevation work (as needed)
- Materials
  + Rust inhibitor (for when reinforcing bars are exposed)
- Repair staff assignment
  + [Unit chief]: 1 person responsible for inspection
  + [Staff]: 3 people
- Repair procedure

1) [Staff] decides the repair location using the inspection hammer and marks it using chalk.
2) [Unit chief] shall check that the above repair location coincides with the inspection result and the maintenance plan.
3) After 2) above, [Staff] shall remove all the flaked concrete.
4) After 3) above, [Unit chief] shall check that all the flaked concrete is removed.
5) If any reinforcing bars are exposed, [Staff] shall apply a sufficient volume of rust inhibitor to them.

b. Repair of water leakage (for tunnels)

- Tools
  + Hammer
  + Chisel
  + Concrete cutter
  + Steel brush
  + Ladder
  + Tools for high-elevation work (as needed)
- Materials
  + Pipe for injection

+ Cement-based quick setting water-stop material
+ Water dilatable rubber
+ Urethane-based medical solution
+ Epoxy resin

- Repair staff assignment
  + [Unit chief]: 1 person responsible for inspection
  + [Staff]: 3 people
- Repair procedure

1) [Staff] shall clean the area using a steel brush and decide on the repair location.
2) [Unit chief] shall check that the above repair location coincides with the inspection result and the maintenance plan.
3) After 2) above, [Staff] shall prepare a groove for caulking using the concrete cutter and chisel.
4) After 3) above, [Staff] shall assemble the injection pipe for the cement-based quick setting water-stop material.
5) After 4) above, [Staff] shall install the cement-based quick setting water-stop material at the location of the crack.
6) After 5) above, [Staff] shall inject the urethane-based medical solution through the assembled pipe.
7) After 6) above, [Unit chief] shall check that no water leaks occur.
8) After 7) above, [Staff] shall inject epoxy resin along the constructed groove.
9) After 8) above, [Staff] shall remove the pipe, and install the water dilatable rubber and pour epoxy resin into this location.
10) In the last, [Unit chief] shall check that no water leaks occur.

c. Repair of structure (for viaducts and tunnels)

- Tools
  + Hammer
  + Chisel
  + Concrete cutter
  + Steel brush
  + Inspection hammer
  + Ladder
  + Tools for high-elevation work (as needed)
- Materials
  + Polymer-based primer
  + Polymer cement-based mortar

+ Aramid continuous fiber sheet

- Repair staff assignment
  + [Unit chief]: 1 person responsible for inspection
  + [Staff]: 3 people
- Repair procedure

1) [Staff] shall decide on the repair location by cleaning the place with a steel brush. If the side face of the repair location is protruding, [Staff] shall cut it off using the concrete cutter.
2) If reinforcing bars are exposed, [Staff] shall process the rusted portions using the steel brush, and apply rust inhibitor to them.
3) [Unit chief] shall check that the above repair location coincides with the inspection result and the maintenance plan.
4) After 3) above, [Staff] shall clean the repair location using water.
5) After 4) above, [Staff] shall apply polymer-based primer to the repair location.
6) After polymer-based primer is dried, [Staff] shall fill the repair location with polymer-based mortar (1st layer). At this point, polymer cement-based mortar must be evenly filled in and adhered to the base metal.
7) After 6) above, [Staff] shall set the continuous fiber sheet on the first layer.
8) After 7) above, [Staff] shall fill the continuous fiber sheet with polymer cement-based mortar (2nd layer).
9) In the last, [Unit chief] shall check that polymer cement-based mortar has adhered firmly to the base material.

Chapter 8: Acceptance Inspection, Quality Evaluation and Monitoring after Completion of Work

- When the given maintenance work is executed by OU, HQ shall check the documents and current conditions after the work is completed. (Including results of the inspection and repairs.)
- When executed by a subcontractor
  + The work must be implemented in conformance with the Vietnam Law, namely Decree No. 46/2015/NĐ-CP on Quality Control of Civil Structure dated 2015/05/12.

Track Maintenance Manual

1. Adjustable Range and Applicable Target

The Track Maintenance Manual herein applies to carry out maintenance work on the track administered by the company.

2. Compliance with Regulations of Vietnam

Our maintenance work shall strictly observe applicable laws in Vietnam concerning track maintenance.

3. Track Maintenance Work

(1) Inspection of tracks

Inspection of tracks is a key phase in track maintenance. Track inspection work provides the grounds for understanding information about the state of tracks and regularity of damage, grounds for creating a maintenance plan, grounds for failure analysis, and grounds for countermeasure development.

(2) Preparation of track maintenance plan

Preparation of the track maintenance plan forms the foundation for assuring orderly and accurate maintenance work, and clarifying the purpose of maintenance. The track maintenance plan consists of a long-term maintenance plan (5 years and 30 years), an annual maintenance plan, a monthly maintenance plan, and a daily maintenance plan.

(3) Implementation of track repairs

Repairs are the second most important type of work included in the preparation of the maintenance plan. This work must include the maintenance and investment in the maintenance plan created previously.

4. Inspection of Tracks

The following 12 types of inspections are defined as shown below.

No.	Contents of inspection	Staff	Inspection tools	Method of implementation	Inspection result Record form	Allowable error
1	Train patrol	Number of staff: 4 Among them + Unit chief: 1 person + A staff member stands in the driver's cabin along with the unit chief. + Two of the staff who carry out the inspection stand behind the unit chief in the passenger car instead of in the driver's cabin.	+ Train in operation + Flashlight	- All the unit staff stand in the train subject to the operation inspection. - The unit chief and a staff stand by the driver in the driver's cabin. - The other two staff stand in the passenger car. - These four inspect the track by observing the front track. - When a failure is found, the chief of the inspection unit tells the driver to stop the train. After the train is stopped, two staff in the passenger car get off the train to carefully inspect the tracks.	Common Inspection Record Form 5.2	
2	Patrol on foot	Number of staff: 4 Among them + Unit chief: 1 person + Number of workers: 2 + Worker responsible for safety checks: 1 person	Inspection hammer - Pen - Measurement Results Recording File - Flashlight - Whistle	- When inspecting the track, all staff walk along the track in the direction opposite to the direction the train is traveling in. They check the track visually for any abnormalities. - Two inspection workers walk along the outside of the track. Each of them inspects a single rail. - The unit chief walks inside the tracks, and confirms and records the inspection results. - The worker responsible for safety checks stands some 50 meters ahead of the inspection team and warns them if a train is approaching. - He warns of an approaching train using a flashlight and whistle. Upon hearing the warning signal, all the inspection unit staff move to a safe train shelter.	Common Inspection Record Form 5.2	
3	Inspection of structure gauge	Number of staff: 4 Among them + Unit chief: 1 person + Worker responsible for driving the structure gauge measurement car: 1 person + Workers responsible for the expanded track tolerance volume: 2 people	Structure gauge measurement car - Pen - Memo pad - Flashlight	- One of the workers drives the measurement car. - When passing a curve, two workers expand the track tolerance. - The unit chief stands behind the two, and confirms and records the inspection results on a memo pad.	No special form is required for use as a memo pad. If a location exceeding the track tolerance is found, the unit chief records the kilometrage of the location and takes its picture.	The track tolerance shall not be exceeded.

4	Inspection of tracks					
4.1	4-item measurement (Gauge, alignment, longitudinal level and cross level)				Four-item Measurement Record Form 5.3	
4.1.1	Measurement of a distance of both tracks	Number of staff: 4 Among them + Unit chief: 1 person + Workers responsible for measurement: 2 people + Workers responsible for recording measurement result: 1 person	- Special measure - Tape - Pen - Memo pad - Flashlight	- This measurement takes place in a location where a straight track turns into a curve. - Two workers measure the distance between track centers. - The unit chief checks the measurement results. - One of the workers records the measurement result.		Widen: < 6 mm Narrow: Limit value > Design value
4.1.2	Gauge measurement	Number of staff: 4 Among them + Unit chief: 1 person + Workers responsible for measurement: 2 people + Workers responsible for recording measurement result: 1 person	- Special measure - Tape - Pen - Measurement Results Recording File - Flashlight	- Workers measure the gauge every 5 m. - The unit chief checks the measurement results. - One of the workers records the measurement result.		+6/-3 mm
4.1.3	Measurement of cross level					<+5/-5 mm
4.1.4	Measurement of alignment	Number of staff: 4 Among them + Unit chief: 1 person + Workers responsible for measurement: 1 person + Workers responsible for stringer work: 2 people	- Special measure - Steel clearance gauge - String - Pen - Measurement Results Recording File - Flashlight	- Workers measure the gauge every 5 m. - Two workers stretch the string and another worker measures the alignment. - The unit chief checks the measurement results and records them in the file.		1/1000
4.1.5	Measurement of longitudinal level	Number of staff: 4 Among them + Unit chief: 1 person + Workers responsible for measurement: 1 person + Workers responsible for stringer work: 2 people	- Special measure - Steel clearance gauge - String - Pen - Measurement Results Recording File - Flashlight	- Workers measure the gauge every 5 m. Two workers stretch the string straight, and another worker measures the height from the string to the rail surface. - The unit chief checks the measurement results and records them.		+10/-10
4.1.6	Measurement of twist	This is calculated from the cross level measurement.				< 12 mm
4.2	Inspection of rail	Number of staff: 4 Among them + Unit chief: 1 person + Number of workers: 3	- Special measure - Steel clearance gauge - Pen - Measurement Results Recording File - Flashlight	- Two workers measure wear of the right side and left side rails every 5 m. - The unit chief checks the measurement results and record them.	Rail Head Wear Inspection Record Form 5.4	< 12 mm
4.3	Inspection of rail crack	Number of staff: 4 Among them + Unit chief: 1 person + Two workers responsible for inspecting cracks/rail damage + Workers responsible for recording inspection results: 1 person	- Steel clearance gauge - Pen - Measurement Results Recording File - Flashlight	- All members of the unit walk along the track. Two workers inspect the track. - The unit chief checks the inspection results. - One of the workers records the inspection result.	Rail Damage Record Forms 5.5, 5.6, 5.7	The following events are observed on the rail head. Width: < 15 mm Length: < 100 mm Depth: < 10 mm
4.4	Inspection of rail damage					

						The following values are observed in the rail bottom. - Reduction in width: < 15 mm - Reduction in thickness: 7 mm
5	Inspection of Turnouts and crossings				Four-item Measurement at Turnout and Crossing Record Form 5.10	
5.1	4-item Measurement Record Form 5.3	Number of staff: 4 Among them + Unit chief: 1 person + Workers responsible for measurement: 2 people + Workers responsible for recording measurement result: 1 person	- Special measure - Tape - Pen - Memo pad - Flashlight - Steel clearance gauge - String - Pen - Measurement Results Recording File	- Workers measure each item (items depend on the design of turnouts and crossings) - The unit chief checks the measurement results and records them.		
5.1.1	Gauge measurement					<+4/-2 mm
5.1.2	Measurement of cross level					<+4/-4 mm
5.1.3	Measurement of alignment					+3/-2
5.1.4	Measurement of longitudinal level					1/1000
5.1.5	Measurement of back gauge					Depends on the design
5.1.6	Measurement of spacing between tongue rail and stock rail					Depends on the design
5.1.7	Measurement of clearance between tongue rail and stock rail					Depends on the design
5.2	Wear inspection of turnouts and crossings	Number of staff: 4 Among them + Unit chief: 1 person + Workers responsible for inspection work: 3 people	- Special measure - Steel clearance gauge - Pen - Measurement Results Recording File - Flashlight	- Two workers measure depth of wear of the rail in the turnouts and crossings at the following locations. + Tongue rail: Left (1 or 2 points) and right (1 or 2 points) + Crossing: At A, B and C + Guard rail: On stock side and turnout side + Lead rail: On stock side and turnout side + Stock rail: On stock side and turnout side + Running rail: On stock side and turnout side - The unit chief checks the measurement results. - A worker records the measurement results in the Wear Inspection File of turnouts and crossings.	Turnout and Crossing Wear Inspection Record Form 5.8	Add the items after confirming the design.
5.3	Flaw inspection of turnout and crossing rails	Number of staff: 4 Among them + Unit chief: 1 person + Two workers responsible for inspecting cracks/rail damage + Workers responsible for recording inspection results: 1 person	- Measure for clearance measurement - Pen - Measurement Results Recording File - Flashlight	- Two workers inspect cracks/damage to the tongue rail and crossing. - The unit chief checks the inspection results. A worker records the information related to cracks/damage in the record file.	Turnout and Crossing Damage Record Form: Crossingand tongue rail: Form 5.9 Other locations: Form 5.5	Add the items after confirming the design.
5.4	Measurement of joint clearance between tongue rail heel and rail	Number of staff: 4 Among them + Unit chief: 1 person	- Measure for clearance measurement - Pen	- Two workers measure the joint clearance. - The unit chief checks the measurement results. - One of the workers records the measurement result.	Tongue Rail Heel and Crossing Toe Joint Clearance	Add the items after confirming the design.

5.5	Measurement of joint clearance between rail and crossing front end	+ Workers responsible for joint clearance measurement: 2 people + Workers responsible for recording inspection results: 1 person	- Measurement Results Recording File - Flashlight		Measurement Recording Form 5.11	Add the items after confirming the design.
6	Inspection of joint					
6.1	Inspection of normal joint	Number of staff: 4 Among them + Unit chief: 1 person + Workers responsible for inspection work: 2 people + Workers responsible for recording result: 1 person	- Steel clearance gauge - Pen - Measurement Results Recording File - Flashlight	- Two workers carry out the inspection. - The unit chief checks the inspection results. - One of the workers records inspection results in the inspection record file.		Widen: < 10 mm Narrow: 0 mm
	+ Joint gap inspeciton				Rail Joint Inspection Record Form 5.12	If any damage is found, the joint must be replaced immediately.
	+ Inspection of joint conditions				Damage on Joint Bar Record Form 5.14	
	+ Joint parts inspection (joint bar, bolt)				Rail Joint Material Inspection Record Form 5.13	
6.2	Expansion joint inspection					
	+ Inspection of expansion joint sonditions	Number of staff: 4 Among them + Unit chief: 1 person + Workers responsible for inspection work: 3 people	- Special measure - Steel clearance gauge - Pen - Measurement Results Recording File - Flashlight	- Three workers carry out the inspection. - The unit chief checks the inspection results and records them.	Expansion Joint Inspection Record Form 5.15	
	+ Expansion joint parts inspection					
7	Inspection of sleeper	Number of staff: 4 Among them + Unit chief: 1 person + Workers responsible for inspection work: 2 people + Workers responsible for recording result: 1 person	- Pen - Measurement Results Recording File - Flashlight	- Two workers carry out the visual inspection of sleepers. - The unit chief checks the inspection results. - One of the workers records inspection results in the inspection record file.		If any problems are found, the cross tie must be replaced immediately.
8	Inspection of fastening system	Number of staff: 4 Among them + Unit chief: 1 person + Workers responsible for inspection work: 2 people + Workers responsible for recording result: 1 person	- Steel clearance gauge - Hammer for inspection - Pen - Measurement Results Recording File - Flashlight	- Two workers visually inspect the fastening system using a hammer and wrench. Check the marking line provided on the fastening device beforehand. - The unit chief checks the inspection results. - One of the workers records inspection results in the inspection record file.	Form 5.2 for overall inspection	If any problems are found, the fastening device must be replaced.
9	Inspection of carbody vibration	Number of staff: 4 Among them + Unit chief: 1 person + Two workers guide the passengers so that they do not come near the vibration indicator. + Workers responsible for operating the vibration indicator: 1 person	- Vibration indicator	- All the unit staff carry out the inspection. - Inspection results shall be assessed after the staff have returned to the office.	Form 5.2 for overall inspection	Add the items if the design documents are available.

10	Inspection of track bed	Number of staff: 4 Among them + Unit chief: 1 person + Workers responsible for inspection work: 2 people + Workers responsible for recording result: 1 person	- Pen - Measurement Results Recording File - Flashlight	- All of the unit staff must check the location where the curve starts as well as the place where the ballast track bed collapsed. - The unit chief checks the inspection results. - One of the workers records inspection results in the inspection record file.	Form 5.2 for overall inspection	If any problems are found, the ballast track bed must be replaced.
11	Inspection of car stop	Number of staff: 4 Among them + Unit chief: 1 person + Workers responsible for inspection work: 3 people	- Pen - Measurement Results Recording File - Flashlight	All the unit staff carry out the inspection and, if any stained or failed portions are identified, they must clean and repair them. - The unit chief checks the inspection results and records them.	Form 5.2 for overall inspection	If any problems are found, the car stop parts must be replaced.
12	Indicator					

5. Track Inspection Form

5.1 Inspection of structure gauge: Form not specified

5.2 Common Inspection Record Form

Between stations	Line name	A line/ B line	Kilometrage (Km)	Left rail/ Right rail	Inner rail/ Outer rail	Inspection result		Quantity	Unit	Remark
						Contents of inspection	State			

5.3 Four-item Measurement Record Form (to be measured every 5 m)

Between stations	Line name	A line/ B line	Kilometrage (Km)	Left rail/ Right rail	Gauge			Cross level			Alignment			Longitudinal level			Twist			Remark
					TK	TT	CL	TK	TT	CL	TK	TT	CL	TK	TT	CL	TK	TT	CL	

:TK Design value; TT: Measured value; CL: Magnitude of irregularity

5.4 Rail Head Wear Inspection Record Form

Between stations	Line name	Date of manufacture	Kilometrage	Straight line/ Curved line	Track Type	Date of laying of rails	Monitored wearing depth of top surface of rail							
							1st year	2nd year	3rd year	4th year	5th year	6th year	7th year	8th year
							Depth of wear	Depth of wear	Depth of wear	Depth of wear	Depth of wear	Depth of wear	Depth of wear	Depth of wear
							Passed tonnage	Passed tonnage	Passed tonnage	Passed tonnage	Passed tonnage	Passed tonnage	Passed tonnage	Passed tonnage

5.5 Rail Damage Record Form

Date failure occurred	Between stations	A line/B line	Kilometrage	Curve radius	Inner rail/outer rail	Type of crack

Date rail was laid	Passed tonnage	Type of rail			Manufacturer	Date of manufacture
		New product Recycled product	50 kg 60 kg	Ordinary rail Heat-processed rail		

Ballast track bed	Type of fastening system	Type of joint	Joint clearance between rails (mm)	Longitudinal level at joint (mm)	Rail wear depth	Remark
					Top surface… mm Running surface… mm	

Description of processing method ---------------
Replacement timing

5.6 Rail Surface Damage Record Form

Inspection date	Monitoring of state of flaws on rail surface (History)	Description concerning progress of damage
Date	*Addition of vertical projection view of rail*	
Date	*Addition of vertical projection view of rail*	
Date	*Addition of vertical projection view of rail*	

5.7 Damage Described on Rail Bottom Record Form

Inspection date	Monitoring of state of damages to rail surface (History)	Description concerning progress of damage
Date	*Addition of the end view of the rail bottom*	
Date	*Addition of the end view of the rail bottom*	
Date	*Addition of the end view of the rail bottom*	

5.8 Turnout and Crossing Wear Inspection Record Form

Inspection date	Date of laying of rails	Tongue rail (Tongue rail)	Crossing (Crossing)	Guard rail (Guard rail)	Lead rail (Lead rail)	Stock rail (Stock rail)	Running rail (Running rail)	Remark

5.9 Turnout and Crossing Damage Record Form (Devices other than the turnout shall be recorded on the Rail Inspection Form).

Date failure occurred	Site of occurrence	Turnout and crossing number	Type of turnout and crossing	Type of track bed

Date of laying of rails	Passed tonnage	Manufacturer	Date of manufacture

Name of finder		Commendation
Repair procedure		Remark
Repair timing		Remark

Inspection date	**Changes in the failed portion over time**
1st time …………………………….	*No description*
2nd time…………………………….	*First description*
3rd time…………………………….	*Description of each of the previous times.*
4th time…………………………….	*Description of each of the previous times.*
5th time…………………………….	*Description of each of the previous times.*
6th time…………………………….	*Description of each of the previous times.*

5. 10 Four-item Measurement at Turnout and Crossing Record Form

Inspection date	Gauge			Cross level			Alignment			Longitudinal level			Check gauge (Check Gauge)		Difference between tongue rail and stock rail	Clearance between tongue rail and stock rail	
	1	…	10	1	…	10	2’	5’	6’	2’	5’	11’	11	12			
																	Design value
																	Measured value
																	Difference between measured and design values
																	Difference between before and after repair
																	Design value
																	On-site measurement
																	Difference between measured and design values
																	Difference between before and after repair

5.11 Tongue Rail Heel and Crossing Toe Joint Clearance Measurement Recording Form

Between stations	Line name	Kilometrage (km)	Measurement of tongue rail heel			Measurement of crossing toe			Remark
			Design value	Left side	Right side	Design value	Left side	Right side	

5.12 Rail Joint Inspection Record Form

Inspection date	Between stations	A line/ B line	Kilometrage	Type of rail	Type of track bed	Longitudinal level of joints (Yes/No)	Rail surface damage (Yes/No)	Deviation of longitudinal level at the top surface of rail	Rail misalignment at joint	Remark

5.1 3 Rail Joint Parts Inspection Record Form

Inspection date	Between stations	A line/ B line	Kilometrage	Inner rail/ Outer rail	Type of track bed	Contents of inspection			
						Type of joint bar and bolt (Joint bar or bolt)	Description (Content)	Description of status (Description of status)	Remark (Remark)

5.14 Damage on Joint Bar Record Form

Inspection date	Between stations	A line/ B line	Kilometrage	Straight line/Curved line R =	Left/Right	Inner/Outer	Type of track bed	Type of crack	Outline drawing	Remark
									Image of joint bar added	
									Image of joint bar added	

5.15 Expansion Joint Inspection Record Form

Inspection date	Gauge			Cross level			Alignment	Longitudinal level	Travel distance				Remark
									Left rail		Right rail		
	1	2	3	1	2	3	2	2	Tongue rail	Stock rail	Tongue rail	Stock rail	

Track Maintenance Plan

6.1 Track Maintenance Plan

6.1.1 30-Year Maintenance Plan

The 30-year plan is formulated in such a way that any extremely large investment costs that occur may be spread across the entire business in such a way that does not threaten safe urban railway operations. In the process of formulation, we can gain an understanding of the trends in repair and investment costs within the entire business. We must also prepare a long-running employment policy based on the 30-year plan.

Every item of urban railway equipment must eventually be replaced. If, however, replacement of a large number of items of equipment is required at the same time, an enormous amount of funds will have to be prepared. Therefore, in addition to the size of annual repair costs, we must coordinate and clearly describe the size of investment costs for equipment upgrades in the 30-year plan based on the durable years of each item of equipment being set during the design phase, and the current state of the equipment checked in daily inspections.

6.1.2 5-Year Maintenance Plan

The goal of this plan is to grasp the actual costs needed for repairs and investment by making relevant aspects more manageable. Making relevant aspects more manageable means to organize things around repairs and investment based on the long-term 30-year plan, inspection-based judgment, and the assumed actual work.

As mentioned above, comprehensive discussions and adjustments must be carried out between the department that creates the budget and the department that requests the budget in order to create a feasible midterm business plan.

The 30-year plan and 5-year plan should desirably be revised annually. In particular, the 5-year maintenance plan must be revised annually. The 5-year plan provides information on what businesses are specifically scheduled during the said period, as well as their order of preference. Therefore, the 5-year maintenance plan becomes a guide for obtaining a clear view of the management situation, not only for the departments requesting budgets but also for all employees, including those in management. In the 5-year maintenance plan, the portion that covers the coming year becomes the plan for the next year.

6.1.3 Annual Maintenance Plan, Monthly Maintenance Plan and Daily Maintenance Plan

Although the maintenance plan describes the work to be implemented during the said year, it is not possible to actually execute the work according to this plan alone. In order to implement the work without delay, we must divide large operations into detailed maintenance work schedules, and decide specifically who does what and when. Accordingly, all maintenance staff members must share the information regarding this situation. Therefore, the work described in the annual maintenance plan must be subdivided into monthly and daily maintenance plans.

Changes in actual maintenance work normally occur because we sometimes need to urgently address the sites that are affected by climate and natural conditions. Changes in the maintenance plan also occur when the scheduled work is not finished on time due to utilization of inexperienced workers. As seen in the above, the work plan is normally repeatedly revised due to various factors.

When implementing maintenance, we need the daily maintenance plan that allocates the day's work to each shift based on the monthly maintenance plan. This daily maintenance plan tells the maintenance staff what they are supposed to do during the day's shift. It also ensures a complete hand-off of jobs between shifts in order to prevent any oversights.

Every maintenance work task carried out in each shift during the day is recorded on the daily maintenance plan. These records are very important information for formulating future plans. Namely we can formulate feasible plans only by analyzing and grasping these records. These records also provide effective information for developing a human resource cultivation plan and an employment plan. Thus, we must accumulate this information and analyze them on a daily basis.

6.2 Person in Charge of Plan Preparation

- Regarding the 5-year and 30-year maintenance plan, HQ shall be responsible for conducting surveys for long-term plans and their development, and OU shall be responsible not only for implementing the plans but also for producing the results.

- The person in charge of plan preparation at OU shall be the creator of the annual and monthly maintenance plans.
- The daily maintenance plan is prepared via discussion between the chief of the repair unit of the preceding shift and the chief of the succeeding repair unit. As necessary, the two chiefs shall consult with the plan preparation engineer.

6.3 Basis for Plan Development

6.3.1 Basis for 30-Year Maintenance Plan Development

- We must estimate how things are broken.
- We must identify from past records how quickly the broken portions are fixed and how many staff are needed to conduct repairs.
- It is also necessary to know from past records the amount of funds required to conduct repairs.

6.3.2 Basis for 5-Year Maintenance Plan Development

- Target fiscal years of the plan
- Classification of businesses
- Budget
- Business number
- Place of work
- Purpose of work
- Description of work implemented
- Request for implementation
- List of items for which difficulties are anticipated during work in the given year.
- Relevant departments whose cooperation is solicited for the work

6.3.3 Basis for Annual Maintenance Plan Development

- 5-year maintenance plan and 30-year maintenance plan
- Results of the annual maintenance plan implemented in the preceding year
- The equipment and machinery data necessary for maintenance and change-related rules that have been accumulated in the past maintenance.
- Results of track inspection
- Regulations on the track maintenance work and other applicable regulations.
- Resources owned by the company (human resources, machines and equipment).

6.3.4 Basis for Monthly Maintenance Plan Development

- Annual maintenance plan
- Results of track inspection
- Results of monthly maintenance plan implemented in the previous month
- Regulations on the track maintenance work and other applicable regulations.
- Resources owned by the company (human resources, machines and equipment).

6.3.5 Basis for Daily Maintenance Plan Development

- Monthly maintenance plan
- Results of track inspections
- Results of the plan for the preceding shift (in the 3-shift a day system. Each shift engages in the development of a day's maintenance plan.)
- Resources owned by the company (human resources, machines and equipment).
- Weather

6.3.6 Precautions for Plan Development

- After the hand-off of the shift every morning, the chief of the repair unit of the morning shift sends the report on the results of the daily maintenance plan executed the previous day to the person in charge of planning. The chief hands off the results of the plan executed the previous day to another unit on the shift.

- Results of the plan executed on a Saturday and Sunday shall be handed off to the first morning shift of the following week, and then reported to the person in charge of plan development.

6.4 Plan and Report Approval Request Procedure (From OU to HQ)

- At OU, each person in charge submits the request for approval of report to the senior officer in the department. (Senior officer refers to the department manager or deputy manager.)
- Then the report is sent to the person in charge of the application section at HQ. After the report is checked by the person in charge of the applicable section at HQ, the report is sent to the senior officer of HQ. (Senior person refers to the department manager or deputy manager of HQ.) After the report is approved by the senior officer of HQ, it is sent back to the senior officer of the applicable department at OU.
- When any revisions are needed for the report, the above procedure also applies.

6.5 Maintenance Plan Form

6.5.1 Long-term Maintenance Plan Form (5-year maintenance plan and 30-year maintenance plan)

No.	Year implemented	Split of work	Classification of businesses	Budget	Place of work	Purpose of work	Description of work implemented	Difficult points	Relevant departments whose cooperation is solicited for the work

6.5.2 Annual Maintenance Plan Form

No.	Item	Types of work (Repair/upgrade)	Monthly workload					Total
			January	February	March	…	December	
1	A	Repair						
2	B	Upgrade						
3	C	Upgrade						
4	D	Repair						
	…							

6.5.3 Monthly Maintenance Plan Form

No.	Item	Types of work (Repair/upgrade)	Daily workload			Materials	Person in charge	Machines
			1st day	…	30th day			
1	A	Repair						
2	B	Upgrade						
3	C	Upgrade						
4	D	Repair						
	…							

6.5.4 Daily Maintenance Plan Form

No.	Item	Types of work (Repair/upgrade)	Workload			Materials	Person in charge	Machines
			1:00	….	24:00			
1	A	Repair						
2	B	Upgrade						
3	C	Upgrade						
4	D	Repair						
	…							

7. Track Repair

Order	Description of repair	Arrangement of staff	Repair tools	Method of implementation
1	**Correction of alignment**	Number of staff: 6 Among them + Unit chief: 1 person + Number of workers: 5	- Special measure - Dolly for construction inspection - Wrench - Hammer - Pen for marking the rail - Steel clearance gauge - String - Measurement Results Recording File - Flashlight	**1. Preparatory work:** **1.1 The measurement range is plus 15 m of the work zone in the front-back direction.** - Explanation of the measurement range Example: Sleepers A, B, C, D, E, and F are the target of the alignment adjustment. Interval is 5 m. Work zone is A to C (10 m). + Reason 1: When alignment of C is adjusted, alignment of D is adjusted in connection with the adjustment of C. When alignment of D is adjusted, alignment of E is adjusted in connection with the adjustment of D. When alignment of E is adjusted, alignment of F is adjusted in connection with the adjustment of E. Therefore, alignment of D, E and F must also be adjusted in addition to work zones A, B and C. + Reason 2: When measuring alignment of C, the string is stretched from B to D. Namely, work zones A, B and C are affected. Therefore, after measurement of D, the string is stretched from C to E to take a measurement. Since C is involved in this measurement, the work zones are affected. So after measuring E, you must stretch the string from D to E to take a measurement. In this way, impact on the work zones is removed. Therefore, you must also measure D, E and F. The distance from work zones A, B and C to F is 15 m. ***(See Figure 2-Measurement Range in the attached table.)*** **1.2 Measure the distance from the survey point on the stock rail side to the reference point.** - Set the survey point on the stock side rail. In a linear location and in the direction in which kilometrage increases, the stock rail shall be the left side rail. In the case of a curve, the stock rail shall be the outer rail. - Measure the distance from the survey point to the reference point set on the structure (in this case, the structure is the bean of an elevated bridge). The reference point is set at the time of construction. **1.3 Gauge Measurement** - Gauge measurement range: Up to 15 m in the front-back direction including the work zone. The measurement is usually conducted at 5 m intervals in the alignment adjustment. **1.4 Inspection of Structure gauge Position** - Reason: In the curve, the alignment adjustment also changes the curve of the stock side rail, thereby changing the direction the train travels. Thus, the position of structure gauge is changed. Therefore, we must check the structure gauge position to secure the structure gauge. If we cannot observe the structure gauge, we must adjust the track. **1.5 Inspection of Fastening System** - Check that all parts of the fastening system are tight. - Check that the bolts are not rusting. If any rust is seen, loosen the bolt once, lubricate it, and then tighten it again. - Make sure the track pad position is not displaced. If displaced, return it to the original position. **1.6 Inspection of Clearance between Joints** - Inspection range: Up to 50 m in the front-back direction including the work zone. **1.7 Inspection of Bolts on Joint Bar** Inspect the bolts on the joint bar. If they have loosened, tighten them. **1.8 Marking Travel Distance on Sleepers and Rails** - In the alignment adjustment, the rail may be compressed both from outside and inside. Therefore, you must mark the compressed distance and direction on the stock side rail. **2. Actual Work** **2.1 Loosen the fastening system of the stock side rail.** **2.2 Install the gauge retention device.** Purpose of this work: To stably maintain the distance between the right and left rails. **2.3 Adjustment of Alignment** - Start your work from the location that requires the largest adjustment.

				- Once adjustment at a location is completed, measure its alignment immediately. If the measurement result is acceptable, finish your work here and move to the next location to carry out alignment adjustment. - The alignment adjustment must be continuously implemented until the work is completed. **2.4 Permanent Tightening of Fastening System** - After all alignment work is completed, tighten the fastening system of the stock side rail. Lubricate the bolts and prevent dust from being pinched by the bolts. **2.5 Measurement of four items** - Measure the four items (gauge, cross level, longitudinal level and alignment) in the work zone to ensure security.
2	**Gauge Adjustment**	Number of staff: 6 Among them + Unit chief: 1 person + Number of workers: 5	- Special measure - Wrench - Hammer - Steel clearance gauge - String - Measurement Results Recording File - Flashlight	**1. Preparatory work** **1.1 Gauge Measurement** - Excessively narrow or wide gauge can cause a train to derail. Normal survey point intervals in the gauge adjustment is 2.5 m. When there is a large variance in the measurement results at 2.5 m intervals, measure the gauge at each cross tie. **1.2 Inspection of Fastening System** - Check that the fastening device is not loosened. - Check that the bolts are not rusting. If any rust is seen, loosen the bolt once, lubricate it, and then tighten it again. - Make sure the track pad position is not displaced. If displaced, return it to the original position. **1.3 Measurement of Alignment** - When adjusting the alignment and gauge at the same time, adjust the alignment first. **1.4 Deciding Work Position** - Decide the work position. - Write the adjustment value on the rail head. - Start the adjustment from the stock rail. In a linear location and in the direction in which kilometrage increases, the stock rail shall be the left side rail. In the case of a curve, the stock rail shall be the outer rail. **2. Actual Work** **2.1 Loosen the fastening system of the stock rail once, and then tighten it again.** **2.2 Loosen the fastening system on the opposite side of the stock rail rather than that of the stock rail.** **2.3 Adjustment of Position of Opposite Side Rail** - Based on the adjustment value written on the stock rail, adjust the position of the opposite side rail. **2.4 Permanent Tightening of Fastening System** - After all alignment work is completed, tighten the fastening system of the opposite side rail. Lubricate the bolts and prevent dust from being pinched. **2.5 Measurement of four items** Measure the four items (gauge, cross level, longitudinal level and alignment) in the work zone to ensure security.
3	**Rail Renewal**	Number of staff: 6 Among them + Unit chief: 1 person + Number of workers: 5	- Over-raise rail shifter - Wrench - Hammer - Winch - Measure - Rail cutter - Rail bending machine - Rail supporting wedge - Oil - Steel clearance gauge - String - Measurement Results Recording File - Flashlight	**1. Preparatory Work** **1.1 Measurement of Length of Replaced Rail** - When measuring the length of a replaced rail, measure it in the head of the rail using a measure. Two workers who engage in the measurement shall pull both ends of the measure. - Measure the rail length a minimum of two times. The error in the above measurement must be 2 mm maximum. If the error is 2 mm or greater, you must repeat the measurement. - This work is carried out at night. **1.2 Measure the offset. Offset must be measured at each of 1/4, 1/2 and 3/4 point.** ***(See the offset measurement in Figure 4 of Attached Table.)*** **1.3 Measurement of Cross-section** - Measure the joint clearance of the joint at the start and end points of the rail. - Measure the discrepancy and unevenness between the start and end points. Discrepancy denotes the difference in the cross direction between two rails at the end points. Unevenness means the difference between two rails in the vertical direction. **1.4 Measurement of New Rail** - Measure the length of a new rail in its head. - Measure the length a minimum of two times. The error shall be 2 mm maximum. **1.5 Cutting and Chamfering of Rail**

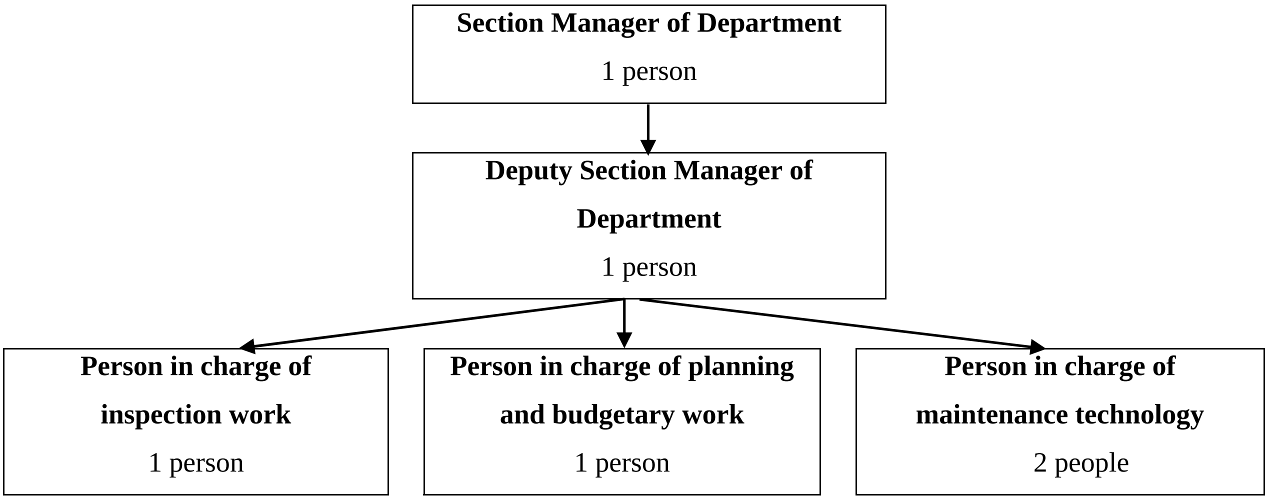
				- Cut the rail using the rail cutter. 2 mm of the end shall be chamfered at an angle of 45 degrees. **1.6 Drilling of Rail Joint** - Drill a hole on the joint of new rail using the rail driller. Chamfer 2 mm wide area of the joint hole at an angle of 45 degrees. **1.7 Setting of Bending of New Rail** - Bend the new rail at each of 1/4, 1/2 and 3/4 point according to the offset specified in Clause 1.2 of this article. - Caution: + When the radius of the rail is less than 600 m, use the bending machine for bending. + Bend the rail to about 2/3 of the offset specified in Clause 1.2 of this article. Exercise care not to bend it excessively. + When the curve radius is more than 600 m and less than 800 m, bend the rail within 5 m from the end. **1.8 Installation of Rail Supporting Wedge** - Install a rail supporting wedge in order to temporarily place the new rail. After bending the rail at Depot, move it to the rail replacement position during the preparation period. - Place the rail outside the track so as not to affect the ballast track bed. Place the rail on the supporting wedge while exercising care not to affect the current bending of the rail. The supporting wedge is made of used, old sleepers. Arrange the pins on the supporting wedge that are used for fixing the rail. **1.9 When replacing two or more rails, you must set the joint clearance of the joints.** - When replacing two or more rails, set an appropriate joint clearance of the joint, and fasten the joint bolts for connecting the rails. In this case, be sure to insert the inner and outer bolts alternately. **1.10 Measure the length of the connected rails.** - Measure the length in the head of the rail. Measure the length two or more times. Measurement error shall be 2 mm maximum. **1.11 Decide Installation Position of Over-raise Rail Shifter** Check the position where the over-raise rail shifter is installed. Decide the position of the over-raise rail shifter in such a way that it can lift a long rail at three points and a short rail at one or two points. Place the supporting wedge of the over-raise rail shifter temporarily in the installation position. **2. Actual Work:** **2.1 Removal of Rail Joint** - On the day of replacement, remove the joints of the rail included in the replacement zone. **2.2 Removal of Fastening System** - Remove the fastening system included in the replacement zone. Exercise care not to pinch any dust. - When removing it, also remove 10 m of adjacent rail. Reason: Axial force settles on the older rail. After the fastening system is removed, that axial force is removed, too. **2.3 Installation Over-raise Rail Shifter** **2.4 Lifting of Rail** - Use the over-raise rail shifter when lifting the replaced rail. Do not lift the rail unnecessarily high. **2.5 Check of Track Pad** - Check that the track pad is set in an appropriate position. When replacing the track pad, replace it using this opportunity. **2.6 Setting a New Rail** - Use the over-raise rail shifter when lifting the new rail. Do not lift the rail unnecessarily high. **2.7 Adjustment of Joint Clearance of Rails** - If the joint clearance of the rail is insufficient, move the rail slightly. How to move it: Pinch the rail in a position slightly away from the position where it was pinched before, and then lift and move the rail. **2.8 Temporary Tightening of Joint Bar Bolts** - After the rail is set in the correct position, tighten the joint bar bolts temporarily. Insert the inner bolts and outer bolts alternately. Lubricate them, and check whether any dust is on the joint bar. **2.9 Move of Replaced Rail to Supporting Wedge** Do not lift the rail unnecessarily high. **2.10 Remove the over-raise rail shifter.** **2.11 Tighten the joint and fastening system.** **2.12 Measurement of Four Items**

				- Measure the four items (gauge, cross level, longitudinal level and alignment) in the work zone to ensure security.
4	**Sleeper renewal**	Number of staff: 6 Among them + Unit chief: 1 person + Number of workers: 5	- Tamping - Wrench - Hammer - Oil - Tool for solidifying the concrete - Measure - Shovel - Concrete breaker - Steel clearance gauge - String - Measurement Results Recording File - Flashlight	**1. Preparatory Work** **1.1 Apply a mark to the sleepers to be replaced. Exercise care not to replace multiple cross tie at the same time.** **1.2 Move new sleepers to the temporary storage space.** **1.3 Check the fastening system,then lubricate and tighten it.** **1.4 If the space between the sleepers is not appropriate or if sleepers are not at right angles to the centerline of the track, adjust the sleepers beforehand.** **2. Actual Work** **2.1 Scrape out the ballast or break up the concrete beforehand.** **2.2 Remove the fastening system of the replaced sleepers.** **2.3 Remove the sleepers to be replaced.** - Remove the sleepers to be replaced. - When ballast is used, rake the ballast. **2.4 Insert new sleepers.** - As a general rule, the center of a cross tie must be aligned with the centerline of the track. - Caution: In the case of a curve, the track centerline is located at a position 717.5 (=1435/2) mm away from the stock rail (outer rail). **2.5 Tighten the fastening system of the new cross tie temporarily.** - Tighten it temporarily after checking that the space between the adjacent cross tie and the cross tie is at a right angle to the track centerline. Then lubricate the bolts. **2.6 Lay out ballast temporarily.** - When using ballast, lay out the ballast. **2.7 Permanent Tightening of Fastening System** **2.8 Tamping down the ballast** **2.9 Level the ballast surface uniformly.** **2.10 Measurement of four items** - Measure the four items (gauge, cross level, longitudinal level and alignment) in the work zone to ensure security.
5	**Tamping down of track bed**	Number of staff: 6 Among them + Unit chief: 1 person + Number of workers: 5	- Tamping - Wrench - Hammer - Oil - Measure - Steel clearance gauge - String - Measurement Results Recording File - Flashlight	**1. Preparatory Work** **1.1 Measurement of four items (gauge, cross level, alignment and longitudinal level)** **1.2 Inspection of fastening system** - Check the fastening system for looseness and rust, and also check the track pad. **1.3 Fill in the ballast for the necessary locations.** **1.4 Adjustment of space between sleepers** - If the space between sleepers is not appropriate or they are not at right angles to the centerline of the track, adjust the sleepers beforehand. **1.5 Measurement of gauge and alignment** **2. Actual Work** **2.1 Lifting of stock rail** - Set a jack for the stock rail from outside the track. - Lift the stock rail up to the specified height. - The stock rail is the inner rail in the curved section. In a linear location and in the direction in which kilometrage increases, the stock rail shall be the left side rail. **2.2 Lifting of opposite side rail** - Set a jack for the opposite side rail from outside the track. - Lift the rail up to the specified height. **2.3 Tamping down the ballast** - As shown in Attached Figure 6, tamp down the ballast in six locations from the position 70 cm away from the cross tie. Tamping shall be continued for 40 seconds per location. Do not press the tamping bar excessively when tamping to avoid damaging the track bed. **2.4 Replenish of ballast.** - After the tip of the tamping bar moves past the bottom face of a cross tie, tamp down the ballast more from a diagonal direction. If the ballast is used up, replenish it.

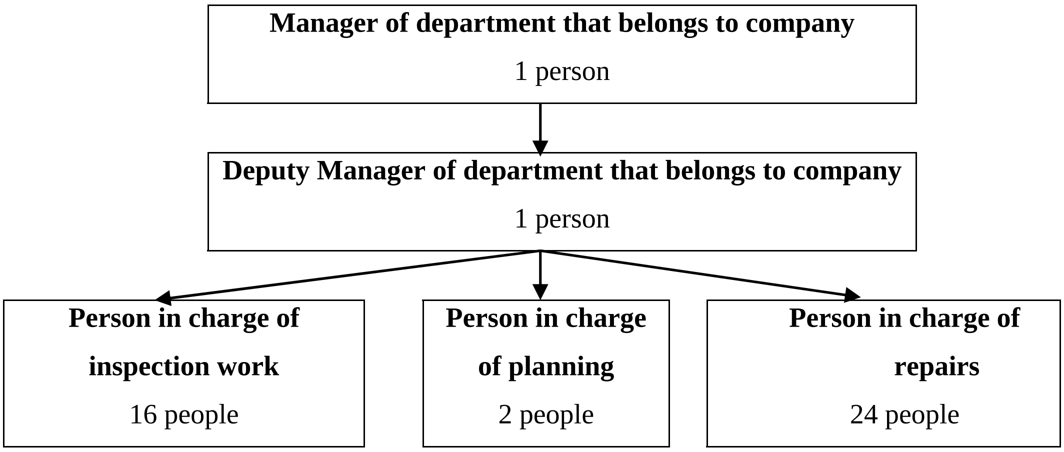
				2.5 Tamping of ballast at A, B, C and D - After tamping the ballast down at A and D, remove the jack to continue tamping at B and C. **2.6 Clean the surface and then level it using the tamping bar.** **2.7 Measurement of four items** - Measure the four items (gauge, cross level, longitudinal level and alignment) in the work zone to ensure security.

8. Organization Chart of Gauge Maintenance Department

+ At HQ



+ At OU



Remark

HQ

- Section Manager of Department: He is responsible for administering the operations at HQ and OU. If the Manager is not available, the duty may be delegated to Deputy Section Manager of the Department.
- Deputy Section Manager of Department: He is responsible for administering and summing operations of each unit of HQ and OU, and reporting these matters to the Section Manager. If not available, the duty may be delegated to each person in charge.
- The people in charge of respective assignments (inspection, planning and budget preparation, and maintenance technology) are responsible for the corresponding assignments at OU, too, and give their reports to the Section Manager and Deputy Section Manager.

OU

- Department Manager: He is responsible for administering the department at OU. If he is not available, the duty may be delegated to the Deputy Manager of the Department.
- Deputy Department Manager at OU: He is responsible for administering and summing up operations of each unit at OU, and reporting these matters to the Department Manager. If he is not available, the duty may be delegated to Unit Chief of each unit of OU.

- Chief of each unit: He is responsible for administering the operations implemented by the unit in his charge, and reporting these matters to the Department Manager and Deputy Manager (OU).

9. Operating Procedure for Inspection, Planning and Repair

9.1 Inspection Work

Step 1: Preparation of the inspection implementation plan based on the maintenance regulations and the maintenance manual.

- Person in charge of inspection at OU (Unit chief)

Step 2: Check of the inspection implementation plan.

- Interpreter: Person in charge of inspection at OU (Unit chief)
- Checker: Department Manager or Deputy Manager of OU

Step 3: Submission of the inspection implementation plan to HQ.

- Submitter: Person in charge of inspection at OU (Unit chief)
- Recipient: Person in charge of inspection at HQ

Step 4: Check of the inspection implementation plan.

- Person in charge of inspection at HQ

Step 5: Approval of the inspection implementation plan.

- Interpreter: Person in charge of inspection at HQ
- Approver: Section Manager or Deputy Section Manager of Department at HQ

Step 6: Restitution of the inspection implementation plan to OU.

- Person responsible for restitution: Person in charge of inspection at HQ
- Recipient: Person in charge of inspection at OU (Unit chief)

Step 7: Execution of inspection based on the inspection implementation plan.

- Primary person in charge: Person in charge of inspection at OU (Unit chief)
- Assistant person in charge: People in charge of inspection at OU

<If there are no problems, go to Step 8>

Step 8: Recording of the results to the inspection implementation plan.

- Person in charge of inspection at OU (Unit chief)

<If the inspection was not able to be carried out in Step 7, change the sequence as shown below.>

Step 7a: Setting of the new inspection implementation date.

- Person in charge of inspection at OU (Unit chief)

Step 7b: Check of the new inspection implementation date and reasons why.

- Interpreter: Person in charge of inspection at OU (Unit chief)
- Checker: Department Manager or Deputy Depertment Manager of OU

Step 7c: Submission of the new inspection implementation date to HQ.

- Submitter: Person in charge of inspection at OU (Unit chief)
- Recipient: Person in charge of inspection at HQ

Step 7d: Check of the new inspection implementation date and reasons why.

- Person in charge of inspection at HQ

Step 7e: Approval of the new inspection implementation date and reasons why.

- Interpreter: Person in charge of inspection at HQ
- Approver: Section Manager or Deputy Section Manager of Department at HQ

Step 7f: Reporting to OU on approval of the new inspection implementation date.

- Reporter: Person in charge of inspection at HQ
- Recipient: Person in charge of inspection at OU (Unit chief)

<Proceed with the inspection returning to Step 7>

Step 9: Entry of the results of evaluation to the form.

- Person in charge of inspection at OU (Unit chief)

Step 10: Confirmation of the evaluation results.
- Interpreter: OU: Person in charge of inspection (Unit chief)
- Checker: OU: Department Manager or Deputy Department Manager

Step 11: Submission of the evaluation results to HQ.
- Submitter: OU: Person in charge of inspection (Unit chief)
- Recipient: HQ: Person in charge of inspection

Step 12: Confirmation of the evaluation results.
- HQ: Person in charge of inspection

Step 13: Approval of the evaluation results.
- Interpreter: HQ: Person in charge of inspection
- Approver: HQ: Section Manager or Deputy Section Manager of Department

Step 14: Restitution of the evaluation results to OU.
- Person responsible for restitution: HQ: Person in charge of inspection
- Recipient: OU: Person in charge of inspection (Unit chief)

Step 15: Preservation of the evaluation results.
- OU: Person in charge of inspection (Unit chief)

Step 16: Submission of a copy of the evaluation results to the person in charge of planning.
- Submitter: OU: Person in charge of inspection (Unit chief)
- Recipient: OU: Person in charge of planning

9.2 Planning Work

(This work is continued from the inspection results of 9.1)

Step 1: Confirmation of the evaluation results and the sites that require repairs, and adjustment of the time necessary for the repairs.
- OU: Person in charge of planning

Step 2: Consultation on the repair method, and requesting a quotation.
- OU: Person in charge of planning

Step 3: Preparation of the business plan based on the organized information.
- OU: Person in charge of planning

Step 4: Check of the business plan.
- Interpreter: OU: Person in charge of inspection
- Checker: OU: Department Manager or Deputy Depaertment Manager

Step 5: Submission of the business plan to HQ.
- Submitter: OU: Person in charge of planning
- Recipient: HQ: Person in charge of planning

Step 6: Check of the business plan.
- HQ: Person in charge of planning

Step 7: Adjustment of the business plan in the company.
- HQ : Person in charge of planning

Step 8: Approval of the business plan.
- Interpreter: HQ: Person in charge of planning
- Approver: HQ: Section Manager or Deputy Section Manager of Department

Step 10: Restitution of the business plan to OU.
- Person responsible for restitution: HQ: Person in charge of planning
- Recipient: OU: Person in charge of planning

Step 11: Development of the annual plan based on the business plan.
- OU: Person in charge of planning

Step 12: Check of the annual plan.

- Interpreter: OU: Person in charge of inspection
- Checker: OU: Department Manager or Deputy Department Manager

Step 13: Submission of the annual plan to HQ.

- Submitter: OU: Person in charge of planning
- Recipient: HQ: Person in charge of planning

Step 14: Check of the annual plan.

- HQ: Person in charge of planning

Step 15: Approval of the annual plan.

- Interpreter: HQ: Person in charge of planning
- Approver: HQ: Section Manager or Deputy Section Manager of Department

Step 16: Restitution of the annual plan to OU.

- Person responsible for restitution: HQ: Person in charge of planning
- Recipient: OU: Person in charge of planning

Step 17: Development of the procurement plan based on the annual plan.

- OU: Person in charge of planning

Step 18: Development of the monthly plan based on the annual plan.

- OU: Person in charge of planning

Step 19: Approval of the monthly plan.

- Interpreter: OU: Person in charge of planning
- Approver: OU: Department Manager or Deputy Department Manager

Step 20: Submission of the monthly plan to the person in charge of repairs.

- Interpreter: OU: Person in charge of planning
- Recipient: OU: Person in charge of repairs (Unit chief)

9.3 Repair and Maintenance Work

(Continued from the plan in 9.2)

Step 1: Development of the daily maintenance plan based on the monthly plan.

- OU: Person in charge of repairs (Unit chief)

Step 2: Implementation of repair based on the daily maintenance plan.

- Primary person in charge: OU: Person in charge of repairs (Unit chief)
- Assistant person in charge: OU: Person in charge of repairs

Step 3: Entry of results of repairs to the monthly maintenance plan.

- OU: Person in charge of repairs (Unit chief)

Step 4: Entry of repair results on the form.

- OU: Person in charge of repairs (Unit chief)

Step 5: Confirmation of results of repairs.

- Interpreter: OU: Person in charge of repairs (Unit chief)
- Checker: OU: Department Manager or Deputy Department Manager

Step 6: Submission of results of repairs to HQ.

- Submitter: OU: Person in charge of repairs (Unit chief)
- Recipient: HQ: Person in charge of repairs

Step 7: Confirmation of results of repairs.

- HQ: Person in charge of repairs

Step 8: Approval of results of repairs.

- Interpreter: HQ: Person in charge of repairs
- Approver: HQ: Section Manager or Deputy Section Manager of Department

Step 9: Restitution of results of repairs to OU.

- Person responsible for restitution: HQ: Person in charge of repairs
- Recipient: OU: Person in charge of repairs (Unit chief)

Step 10: Preservation of results of repairs.

- OU: Person in charge of repairs (Unit chief)

Step 11: Submission of a copy of results of repairs to the person in charge of planning

- Submitter: OU: Person in charge of repairs (Unit chief)
- Recipient: OU: Person in charge of planning

Step 12: Analysis of results of repairs.

- OU: Person in charge of planning

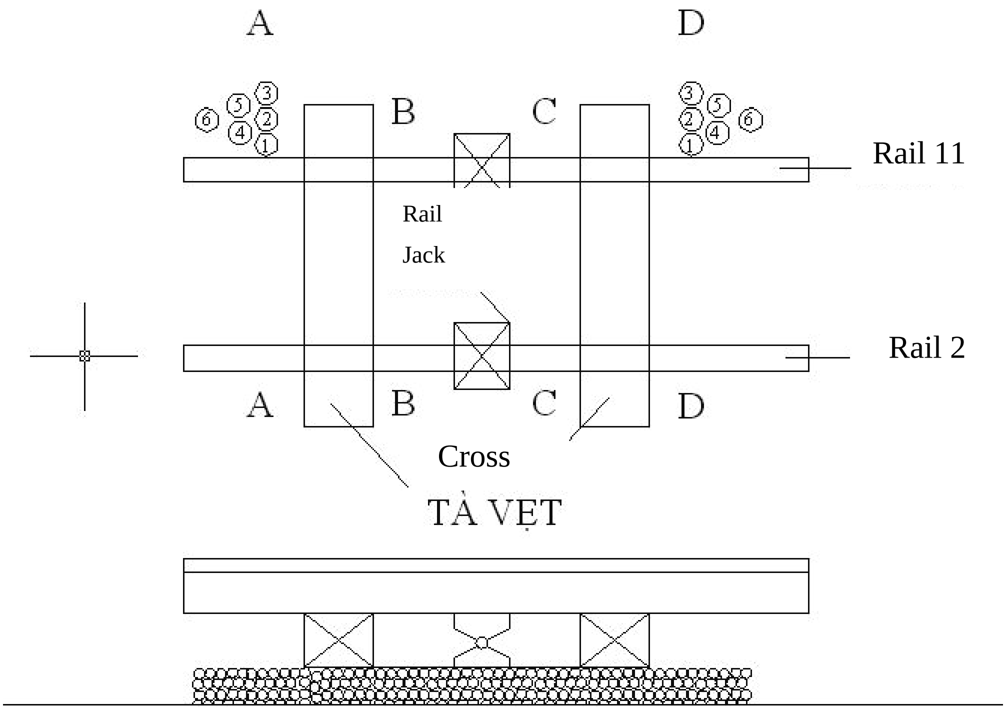
Step 13: Modification of the annual plan in consideration of results of repairs.

- OU: Person in charge of planning

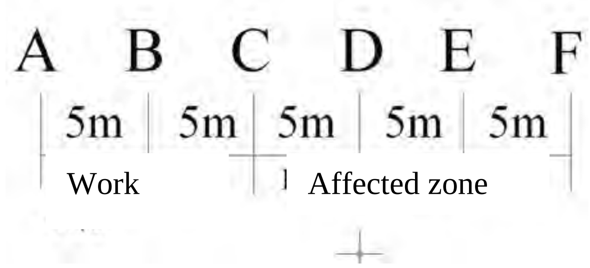
Step 14: Repetition of Steps 12 and after (the plan portion).

Attachment:

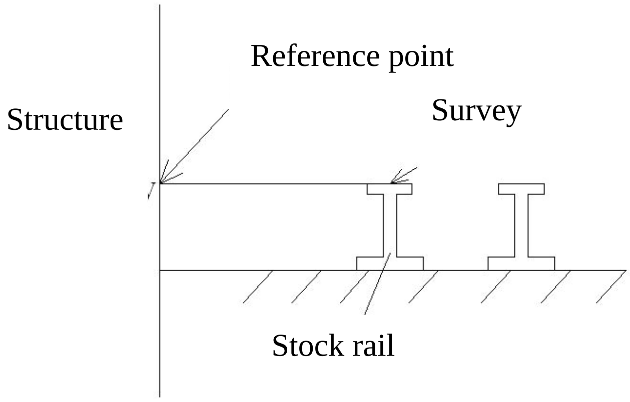
1. Figure 1: How to Tamp Down Ballast



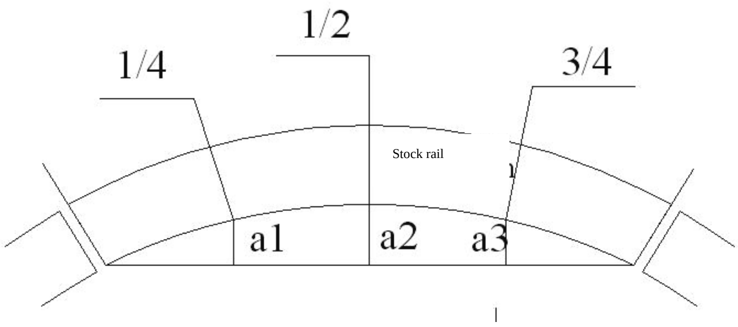
2. Figure 2: Measurement Range



3. Figure 3: Measurement of Clearance between Reference Point and Survey Point



4. Figure 4: Offset is measured at the positions of 1/4, 1/2 and và ¾ (a1, a2 and a3).



JICA-Supported Project of Reinforcement of Urban Railway Regulatory Agency and Establishment of Operating Company in the City of Hanoi

Materials:

Draft of Equipment maintenance rule 〈communication equipment, signal equipment, electric power equipment and station equipment〉

Implementer: Nguyen Viet Quan

JICA TA Team: Mr Takeshi Ikeda

November 30, 2015, in Hanoi

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Part8: Forms and Appendices

Appendix 1: Outline of Coverage of Equipment Management in the Equipment fields of Communication, Signal, Electric power and Station

Appendix 2: Internal rule of Equipment Section on Response to Accidents and Transportation-related Problems

Part 1: Purpose

Article 1 Purpose

The Maintenance rule in the Fields of Communication, Signal, Electric power and Station Equipment set down the requirements for Equipment maintenance work in order to ensure stable operation of the facilities and maintain the technological functions for the safe railway transportation.

Part2: Applicable Scope and Target

Article 2 Adjustment Range

The Equipment maintenance rule herein specify the requirements for maintenance work in the fields of communication, signal, power and station equipment. Hereinafter, the above is referred to as the Equipment maintenance rule.

(See Appendix 1 for the outline of coverage of equipment management in the fields of communication, signal, electric power and station equipment.)

Article 3 Applicable Scope and Target

1. Applicable scope: The rule herein shall be observed in the equipment maintenance processes except where priority is placed on the relevant laws. Where a conflict occurred between the laws and the rule herein due to an amendment of the laws, priority shall be given to the laws rather than the rule.
2. Target: The rule herein apply to internal and external work places, organizations and individuals that are related to maintenance activities of the urban railway administered by HMC.

Part3: Definition of Terms and Abbreviations

Article 4 Interpretation of Terms and Abbreviations

1. Interpretation of terms

Equipment denotes the communication equipment, signal equipment, electric power equipment and station equipment.

Communication equipment is the provision used to ensure safe operation and provide communication for passenger service.

Signal equipment consists of the interlocking device and the signal system that controls trains for the safe operation.

Electric power equipment is the provision that supplies power from a distribution board to each station's equipment and power to trains for travel from an electric power substation.

The electric room of a station is the room containing equipment that supplies power to station equipment.

The electric room of a depot is the room containing equipment that supplies power to depot equipment.

Station equipment refers to the electrical equipment under the supervision of a station except AFC equipment, communication equipment and signal equipment.

Equipment maintenance refers to work processes necessary to ensure and maintain normal operations of equipment as specified in the course of business transactions. Equipment maintenance work includes inspections, maintenance, repairs and quality verification of equipment.

Inspection means identifying the condition of equipment either by using intuition or by use of specialized tools in order to identify a failure or potential failure, and requesting recovery-related actions when a failure is detected.

Periodic inspections involve inspecting each item of equipment based on the cycle specified for them in order to maintain them in normal condition up to the next inspection.

Extraordinary inspection refers to an inspection other than the periodic inspection that takes place as needed in the wake of an accident, equipment modification or disaster.

Maintenance denotes the activities of monitoring, maintaining and repairing equipment on a continual or regular basis in order to ensure normal operation of each item of equipment and to reduce potential failures.

Repair is the activity of fixing failures that have occurred in the course of equipment operation to ensure safe railway operations. Repair comprises both periodic and extraordinary repair work.

Periodic repairs refer to replacement of a section or part, or adjustment that is carried out on a regular basis according to the specified troubleshooting or maintenance procedure of each item of equipment.

Extraordinary repairs are carried out when a safe rail transportation is affected by an accident, transportation-related problem, disaster, etc.

Design quality validation inspects and validates the quality, and evaluates compliance of the given item of equipment with the relevant design requirements.

Maintenance staff denotes the Manager, Deputy Manager, Section Engineers, Leaders and workers at the Center.

The maintenance plan is a table that summarizes necessary maintenance work processes being planned in chronological order. The maintenance plan comprises the inspection plan, maintenance plan, repair plan and budget plan.

Patrol is the work of identifying environmental changes as well as the condition of equipment installed in a particular location that requires maintenance to help ensure equipment is managed appropriately and accidents are prevented.

The Equipment Inspection Standard Table contains the inspection items indispensable in the periodic inspection.

The Inspection Base Date refers to the day designated for the periodic inspection.

The Inspection Base Dates Management Table is used to control the inspection base date for every item of equipment.

The Periodic Inspection Roadmap is a table that summarizes the longest inspection cycle set for each item of equipment in the equipment inspection standard table.

Monthly Workload Planning shows the maintenance work of a month in table form.

Annual Workload Planning shows the maintenance work of a year in table form.

Long-term Workload Planning shows the multi-year maintenance work in table form.

Inspection Table is used to record results of the equipment inspection.

Work Instructions provide instructions necessary during equipment maintenance.

The operating Report is used to report the result of the completed equipment maintenance.

Equipment Maintenance Manual describes the procedures, precautions, manual work procedures, operation method, etc. necessary to carry out equipment maintenance.

2 Abbreviations

HQ: Headquarters

OU (Operation Unit): Local companies

BGTVT: Ministry of Traffic and Transportation

BCA: Ministry of Public Safety

BCT: Ministry of Industry and Commerce

BLĐTBXH: Ministry of Industrial Injury and Society

ĐSĐT: Urban railway

QCVN: National Technical Criteria

TCVN: National Technical Standard

TCCS: Base Criteria

QTKĐ: Verification process

ATC: Automatic Train Control

ATO: Automatic Train Operation

ATS: Automatic Train Supervision

ATP: Automatic Train Protection

PAS: Public Address Systems

AWS: Automatic Warning System

....

Part4: Legal Foundation and Relevant Materials

Article 5 Legal Foundation and Relevant Materials

1. Legal Foundation

- Vietnam Railway Act of 2005

The provisions of the rule herein shall be in compliance with the laws of Vietnam. MOT is currently preparing the rule and standards concerning operation and maintenance of urban railways. After the rule and standards are revised and established, our rule shall be adjusted in accordance with the above.

2. Relevant Materials

- Circular No.20/2013/TT-BGTVT dated August 16, 2013 on rule on Management and Maintenance of Railway Structures.
- Circular No.05/2015/TT-BGTVT date March 30, 2015 on rule on Office Organization of Those Who are Directly Engaged in Operation of Urban Railway.
- Circular No. 52/2014/TT-BCA on Management, Storage and Maintenance of Fire Extinguishing Means.

- Circular No. 07/2014/TT-BLĐTBXH on Announcement of Technological Safety Verification Process 27 of Machines and Equipment that are under the jurisdiction the Ministry of Labor, Disabled Veterans and Society, and are required to satisfy stringent safety requirements.
- Circular No.21/2015/TT-BGTVT on Working Time and Break Time of Employees Who Engage in Specific Operations in Railway Transportation.

National Technical Standard No. QCVN 08:2015/BGTVT on Railway Business.

National Technical Standard No. QCVN 06:2011/BGTVT on Railway Signal.

- Standard QCVN No. 09:2010/BTTTT on Earth Connection at Communication Site.
- National Technical Standard QCVN No. 01:2008/ BCT on Electric Safety.
- Standard QCVN No. QĐT-5: 2009 on Verification of Electric System Facility.
- National Technical Standard QCVN No.02:2011/BLĐTBXH on Labor Safety relevant to Electric Elevators.
- National Technical Standard QCVN No. 11:2011/BLĐTBXH on Labor Safety related to Escalators and Conveyors for Carrying Humans.
- Escalator Safety Technology Verification Standard QTKĐ No. 002:2008/BLĐTBXH.
- Electric Elevator and Hydraulic Elevator Safety Technology Verification Standard QTKD No. 003:2008/BLĐTBXH, and National Technical Standard TCVN 8585:2011 on High-Speed, Mass Transit and Large Weight type Urban Railway.
- Basic Standard TCCS No.01:2009/VNRA on Design, Implementation and Acceptance Inspection of Railway Communication and Signal Construction Work.
- Ordinary Railway Structures Maintenance Standard TCCS 02:2014/VNRA.
- Seamless Railway Structures Maintenance Standard TCCS 03:2014/VNRA.
- Standard TCCS 05:2014/VNRA on Resources, Materials and Accessory Items used in Railway Maintenance Work.
- Railway Communication Facilities Maintenance Standard TCCS 08:2014/VNRA.
- Railway Signal Facilities Maintenance Standard TCCS 09:2014/VNRA.
- Standard TCCS 10:2014/VNRA on Resources, Materials, Equipment and Accessory Items used in Railway Communication and Signal Maintenance Work.
- Technical specifications and materials provided by the equipment suppliers.
- Technology design of Line 2A (Cat - Linh-Ha Dong) equipment- A Chinese consultant
- Technology design Line 3 (Nhon-Hanoi Station) equipment - A French consultant.
- Technology Design of Line 2 (Nam Thang Long-Tran Hung Dao) equipment - A Japanese consultant.

Others are reference materials from TA project.

Part5: Responsibility for Implementation

Article 6 Responsibilities of Each Section

1. HQ Equipment Section:

It shall audit and supervise each Equipment Inspection and Repair Center to implement the equipment maintenance according to the approved plan, regulation and procedure.

2. Equipment Section at OU (each Equipment Inspection and Repair Center):
It shall implement the equipment maintenance according to the plan, procedure and the rule.
3. Other Sections
Other sections shall, in cooperation with HQ Equipment Section, administer the inspection, confirmation and management processes are implemented according the rule so that safe operation of the trains may be ensured.

Article 7 Procedures for Revision and Abolition of rule

1. The Manager of the Center (OU) shall propose his opinion, if any, on revision of or addition to the rule to the Equipment Section Manager (HQ).
2. The Equipment Section Manager (HQ) shall study and review such a proposal from OU, and submit it with his opinion to the top management for their review.
3. The revision and abolition of the rule shall be decided by the President of the General Employees Meeting in accordance with the procedures stipulated in the law.

Part6: Body Text of rule

Chapter 1: Requirements for Facilities and Maintenance Staff

Article 8 Requirements for Maintenance Facilities

1. Maintenance tools, devices and facilities must be kept in good condition at all times.
2. Special equipment for an emergency purpose must be kept in a separate place, and attached with a clear indication and appropriate guidance.
3. Spare equipment must be kept in a separate place, and their quantity and quality must be capable of meeting sudden needs at any time.

Article 9 General Requirements for Maintenance Staff

1. The maintenance staff must have sufficient work-related knowledge and skills, and they must be physically and mentally strong enough to carry out the required maintenance work.
2. Before starting the work, the maintenance staff must get properly dressed, prepare necessary equipment and tools, and adjust the time appropriately.

Article 10 Requirements for Manager of Equipment Inspection and Repair Center

The Manager of the Equipment Inspection and Repair Center shall assume the total responsibility for supervising every operation performed at the Center, and guide the Center employees in such a manner that they may appropriately implement the assignments. The Manager is responsible for every operation including the safety, service, emergency inspections and repairs, and buildup of culture. For this reason, the Center Manager must meet the following requirements.

- Has a college education or above, and has an expert knowledge and experience in equipment management
- Is knowledgeable in the applicable laws and rule, and complies with the rule of the organization.
- Has the ability to improve oneself via study, a good imagination, and the ability to be diplomatic when negotiating. Has sufficient decision-making abilities, exercises leadership, and has a personality type suitable for a management role.

Article 11 Requirements for Deputy Manager of Equipment Inspection and Repair Center

The Deputy Manager of Equipment Inspection and Repair Center must assist the Center Manager in every work. The Deputy Manager assists the Center Manager to help ensure safety, production and service, and implementing emergency inspections and repairs as well as well as to help build company culture. For this reason, the Deputy Manager of the Center must meet the following requirements.

- Has a college education or above, and has an expert knowledge and experience in equipment management
- Is knowledgeable in the applicable laws and rule, and complies with the rule of the organization.
- Has the ability to improve oneself via study, a good imagination, and the ability to be diplomatic when negotiating.

Article 12 Requirements for Section Engineer

The Section Engineer must possess sufficient technical capabilities to handle every type of problem that may occur on equipment in his charge. For this reason, the Section Engineer of the Center must meet the following requirements.

- Has expert knowledge on the system principles of respective equipment. - Has expert knowledge about the technical processes, technical standards and recovery countermeasures against urgent accidents, and has a high degree of skill in handing software for office use as well as sophisticated special software such as CAD.
- Has the ability to improve oneself via study, a good imagination, and the ability to be diplomatic when negotiating.

Article 13 Requirements for Workers

The workers are responsible for implementing maintenance of each item of equipment according to the rule and procedures specified by the company, and rescuing passengers urgently and directly should an accident or failure occurred. For this reason, each worker must meet the following requirements.

- Has high school education or above
- Has expert knowledge, qualification or certificate for the related equipment.
- Has the ability to improve oneself via study, a good imagination, and complies with organization rule.

Other than the above, the Leader of the workers must have sufficient capabilities and experience in issuing instructions to the workers regarding work to be done.

Article 14 Education and Training of Maintenance Staff

The Manager of the Inspection and Repair Center shall develop the worker education and training programs to ensure better implementation of maintenance.

Chapter 2: Patrol and Inspection

Article 15 Equipment Patrol

1. Patrols must be carried out on a constant basis to prevent equipment failure.
2. When a natural disaster that will affect the equipment operation is anticipated, the maintenance staff must grasp and follow up the condition of equipment by patrol, and prepare recovery measures on a timely basis.

Article 16 Equipment Inspection

1. Every item of equipment must be inspected according to the specified procedure.

2. After the equipment inspection, the maintenance staff must input evaluation of the obtained information to the Inspection Table to enable follow up of the equipment operating condition in the use process.

Article 17 Periodic inspection

The periodic inspection must be conducted according to the inspection cycle that is set for each item of equipment in the Equipment Inspection Standard Table, and ensures inspected equipment remains in good condition until at least the time of the next inspection.

Article 18 Contents of Periodic Inspection

The periodic inspection comprises the overall equipment and the detailed equipment inspection. The following describes contents of the inspection.

1. The overall equipment inspection checks and evaluates the condition of equipment comprehensively based on the inspection staff's feeling about operating sounds, noises, operation and setup of the equipment.
2. The detailed equipment inspection checks and evaluates the condition of equipment in detail according to the set procedure after equipment is stopped.

Article 19 Setting of Inspection Base Date

The inspection base date is the date on which the periodic inspection is executed as specified. When the periodic inspection is not executable on the specified date, the inspection staff must select another day within the tolerable period specified in the following table.

Table of Tolerable Periods

<table>
<tr><th>Inspection cycle</th><th>Tolerable period (Before or after)</th></tr>
<tr><td>Half a month</td><td>3 days</td></tr>
<tr><td>1 month</td><td>7 days</td></tr>
<tr><td>2 months</td><td rowspan="3">14 days</td></tr>
<tr><td>3 months</td></tr>
<tr><td>4 months</td></tr>
<tr><td>6 months</td><td>30 days</td></tr>
<tr><td>1 year</td><td rowspan="7">The inspection must take place during the month in which the base date is set.</td></tr>
<tr><td>1.5 years</td></tr>
<tr><td>2 years</td></tr>
<tr><td>3 years</td></tr>
<tr><td>4 years</td></tr>
<tr><td>5 years</td></tr>
<tr><td>6 years</td></tr>
</table>

Article 20 Management of Inspection Base Date

1. The Manager (OU) must appropriately set the inspection base date for every item of equipment managed by the Center. The Manager then summarizes the dates into the Inspection Base Dates Management Table.
2. When changing the inspection base date, the maintenance staff shall set another date within the inspection cycle of the equipment concerned, and correct the date in the Inspection Base Dates Management Table to record the change.
3. A change in the Inspection Base Dates Management Table must be approved by the Center Manager.

Article 21 Change of Periodic Inspection Date

1. When the periodic inspection is not executable on the inspection base date, the maintenance staff must set another date in its place.
2. Such changes must be recorded in the Monthly Workload Planning.
3. Such changes must be reported to and approved by the Center Manager.

Article 22 Extraordinary Inspection

An extraordinary inspection may be regarded as the periodic inspection when its contents are the same as that of the periodic inspection.

Article 23 Implementation of Extraordinary Inspection

1. When an item of equipment is newly installed, improved or repaired.
2. When a disaster occurred.
3. When an abnormality is detected or suspected on an item of equipment.
4. When using an item of equipment again that has been out of service for some time.

Chapter 3: Maintenance

Article 24 Precautions regarding Maintenance

Maintenance staff must inspect the equipment, follow up on inspections, and immediately take preventive measures against the detected defects to ensure safety of trains.

Article 25 Maintenance

Equipment maintenance must be executed in accordance with the procedures and rule to reduce potential failure of the equipment.

Article 26 Classification of Maintenance

Equipment maintenance includes daily maintenance and the periodic maintenance.

Chapter 4: Repair

Article 27 When Multiple Functions of the Equipment Failed

When a certain function of an item of equipment failed due to a natural disaster or transportation-related problem, the maintenance staff must recover the normal state by repairing it ahead of time in order to ensure safe operation.

Article 28 Implementation of Periodic Repair

The maintenance staff must abide by the work instructions when executing the periodic repair.

Article 29 Implementation of Extraordinary Repair

The maintenance staff must abide by the instructions of the leader at the site when executing extraordinary repairs.

Article 30 Completion of Repairs

After repairs are completed, the maintenance staff must prepare an Operating Report detailing the contents of repairs and the methods used.

Chapter 5: Acceptance Inspection and Check of Equipment Functions

Article 31 Work Required after Extraordinary Maintenance

1. The maintenance staff must run the equipment for tests and, as needed, run a trial on the train.
2. Inspect and confirm other relevant equipment.
3. Write an Operating Report detailing the work contents clearly.
4. Recheck the position of the equipment installed in the vicinity to the track so that the track clearance may not be affected.

Article 32 Check of Equipment Functions

Verification of the safety and equipment function must be carried out by the Section Engineer of the Center in accordance with the work instructions approved by the Center Manager.

Part7: Rule on Document Retention Period

Chapter 1: Documents

Article 33 Operating Report

After the work is completed, the Operating Reports that have been approved by the Center Manager are saved and submitted to HQ on a regular basis.

Article 34 Inspection Table

The Inspection Table must be retained at a minimum until the succeeding three inspections are completed. However, when the inspection cycle is less than a year, the Inspection Table must be retained for three years minimum.

Article 35 Technical Documents of New Equipment

When an item of equipment is newly installed, upgraded or improved, its data must be updated and retained for reference purposes for future maintenance work.

Article 36 Technical Documents of Old Equipment

The documents shall be retained for the period provided in the law.

Article 37 Important Documents

The Equipment Section Manager (HQ) may extend the specified retention period for the documents considered important and necessary.

Article 38 Organization of Materials

Documents used for maintenance must be put in order with clear indications so that they can be referenced when needed. In addition, a person in the section should be designated to manage and control documents.

Article 39 Information Aggregation

The maintenance staff shall aggregate the equipment-related information and experience acquired from recovering from failures, as well as solutions for future reference.

Article 40 Reporting and Sharing of Information on Accident and Others

When an accident occurs, the Equipment Section staff of HQ and the maintenance staff of OU shall report and supply information on it in accordance with the company's rule and procedures.

Chapter 2: Others

Article 41 Cleaning

The equipment room must be kept clean all of the time. These rooms must be cleaned periodically to ensure good operating condition and warranted durable years of the equipment and parts.

Article 42 Temperature and Humidity

The temperature and humidity of the equipment room must be kept at the specified level. When changing the temperature and humidity to fix a failure, the maintenance must finish their work as soon as possible so that the equipment may not be affected.

Article 43 Environment

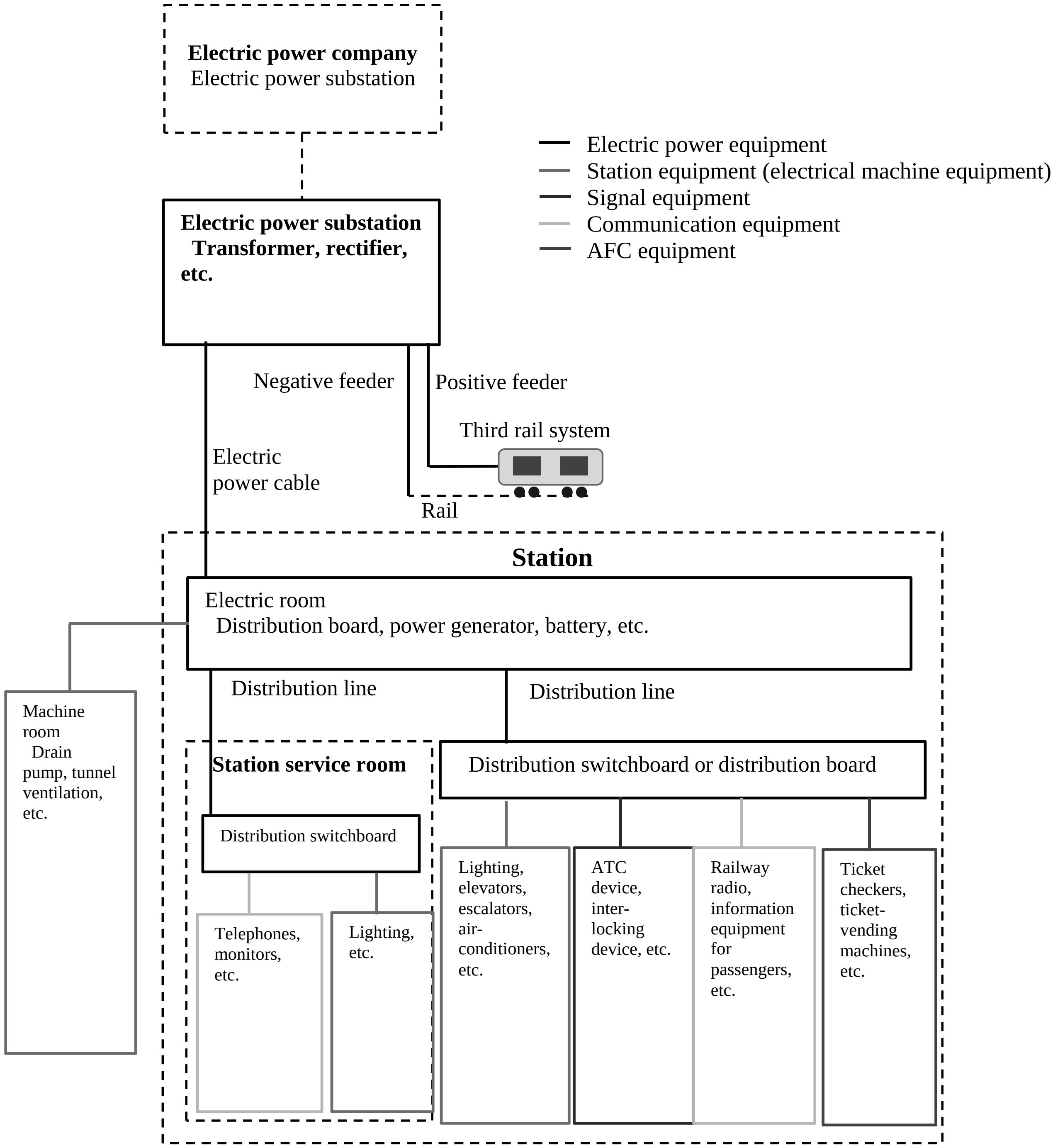
Noises, vibrations or odors generated in the process of carrying out maintenance must not exceed the values allowed in the regulation to protect people living or working nearby.

Article 44 Response to Accident and Transportation-related Problems

The maintenance staff shall observe the accidents and transportation-related problems response rule specified by the law and company. The equipment maintenance staff shall observe the internal rule on accidents and transportation-related problems response specified by the Equipment Section.

(See Appendix 2 for the Internal rule of Equipment Section on Response to Accidents and Transportation-related Problems.)

Appendix 1: Outline of Coverage of Equipment Management in the Fields of Communication, Signal, Electric power and Station Equipment



Appendix 2: Internal rule of Equipment Section on Response to Accidents and Transportation-related Problems

Internal rule of Equipment Section on Response to Urban Railway Accidents and Transportation-related Problem

Part 1 General Provisions

Article 1: Purpose

The rule herein are stipulated in detail to enable the Equipment Section staff to proactively prevent urban railway accidents and transportation-related problems, respond appropriately to such, and achieve safe and stable train operation.

Article 2 Target People

Staff of the Electric Department shall observe the rule herein in addition to the company rule.

Article 3: Explanation of Terms

HQ **refers to Headquarters.**

OU (Operation Unit) denotes Local companies

Equipment Section staff refers to all the staff that belong to the Equipment Section of HQ and OU.

DSDT is the acronym of the urban railway.

Urban railway traffic accident refers to problems caused by railway transportation means that negatively impact human life and/or health, or property as a result of a collision, derailment, or over-turning. A collision in this context includes that with people, other transportation means, and obstacles.

Transportation-related problems are problems that occur during the execution of transportation activities of an urban railway. However, these are not categorized as a railway accident although they do affect railway operations.

Classification of Urban Railway Accidents and transportation-related problems:

- Classification by cause: Subjective causes and objective causes
- Classification of urban railway accidents by nature: Train operation accidents and other accidents
- Classification by damage level: Not so serious accident, serious accident, fairly serious accident and extremely serious accident

Classification of transportation-related problems in an urban railway:

- Classification of transportation-related problems by cause: Subjective causes and objective causes

The Equipment Section shall define accidents and transportation-related problems more specifically and clearly to help ensure appropriate efforts are made to rectify the given problem.

Accident refers to the event in which train operations, railway facilities, passengers, employees, etc. are negatively affected in one way or another.
Near accident case refers to an event that could have ended in an accident although it was prevented thanks to recovery and handling measures taken on a timely bases.

Chapter 2: Proactive Prevention of Accidents and Transportation-related Problems

Article 4: The Equipment Section staff must be conversant in relevant handling and reporting procedures when an accident or transportation-related problem occurs.

Article 5: The Equipment Section staff must execute the maintenance work processes in accordance with the relevant procedures and requirements in order to prevent occurrence of an accident or transportation-related problems.

Article 6: The Equipment Section staff must try, on a consistent basis, to enhance the capabilities and qualification in management and execution of maintenance in order top prevent occurrence of an accident or transportation-related problems that are to be avoided.

Chapter 3: Response to Accidents and Transportation-related Problems

Article 7: When an accident or transportation-related problem(s) occurs, the highest priority shall be given to preventing the damage from spreading, and securing the safety of passengers and employees.

Article 8: When an accident or transportation-related problem(s) occurs, recovery efforts shall put safe and prompt train operations first. Without regard to the full recovery of equipment, precedence shall be given to deployment of staff and emergency treatment by them, and temporary recovery.

Article 9: The Equipment Section staff shall take a series of actions provided in Articles 15, 16 and 17, namely reporting, communicating with others, holding conferences, exercising vigilance and keeping guard.

Article 10: HQ Manager and OU Manager must formulate beforehand the emergency security plan for accidents, transportation-related problems and disasters.

Article 11: The emergency security plan must cover the following factors.

1. Data of the locations that require our caution and attention.
2. List of contact addresses of employees and other departments in the company (during normal hours and in times of emergency)
3. Internal contact system (walkie-talkies, internal telephones, hot-lines, etc.)
4. List of external business partners for emergency response
5. List of equipment and materials for temporary recovery

Article 12: The HQ Manager and OU Manager shall develop the education and training plan on the following subjects for the staff.

1. Training on accident response
2. Training on disaster response
3. Training on execution of temporary measures and recovery
4. Training on rescue and aid
5. Making sure that the staff have sufficient qualifications and capabilities.

Article 13: If an urban railway accident or transportation-related problem occurs, the HQ Manager and OU Manager order the relevant employees to stop the maintenance work or construction work. Upon receiving the order, the relevant employees stop the maintenance work or construction work, and take necessary actions according to the instructions received from the HQ Manager and OU Manager.

Article 14: If an accident or disaster occurs or threatens to occur, the HQ Manager and OU Manager shall take the following measures.

1. When an accident or disaster occurs:

a. Prevent damage from spreading

b. Rescue and evacuation guidance

c. Notification to related organizations

d. Implementation of temporary measures

2. When an accident or disaster threaten to occur:

a. Vigilance and guard by patrol, etc.

b. Development of response plans

Chapter 4: Reporting on Accident and Transportation-related Problems

Article 15: If an accident or disaster occurs or threatens to occur, the OU Manager shall make the following reports to the HQ Manager and HQ Deputy Manager in charge. The OU Manager shall following the special instructions, if any, from the HQ Manager and HQ Deputy Manager in charge. The necessary report shall also be produced for OCC.

1. Prompt report

It is to report an accident occurred immediately. The means of notification may be phone or mail at the point of occurrence. After the prompt report, the OU Manager shall describe the accident using the prompt report form (Form 1) and submit it to the relevant departments within a day in principle.

2. Interim report

The OU Manager shall describe the accident's survey status and emergency measures taken using the interim report form (Form 2) and submit it to the relevant departments within seven days in principle.

3. Final report

The OU Manager shall describe the survey results and permanent measures using the final report form (Form 3) and submit it to the relevant departments within 14 days in principle.

4. The OU Manager shall attach drawings, blueprint, measurement records and photos to the report to help quick and accurate understanding of the accident.

Article 16: After receiving the report from the OU Manager, the HQ Manager shall summarize and evaluate it, and submit the report (Form 4) to the government agency and related organizations.

Article 17: When occurrence or potential occurrence of an accident or transportation-related problem is detected, the staff of the Electric Department shall report it according to rule to the supervisor in order to receive his instructions.

Article 18: The report shall be retained for the period stipulated in the Conservation Act.

Chapter 5: Articles for Implementation

Article 19: The Equipment Section of HQ has the right to adjust or modify these rule in order to reflect actual situations.

Article 20: The Manager of the Center may propose modifications of these rule based on reality of the companies for work-site operations under his supervision.

Appendix - Reference Materials and Report Forms

A. Reference Materials

Accidents and transportation-related problems classification table of Electric Department (including multiple cases)

	Cause	Nature	Specific examples
Urban railway accident	HMC is subjective	Caused by railway facility, etc.	Due to age-related deterioration, the motor of the ventilation system had overheated and caused a fire, which affected train operations.
Same as above	Same as above	Caused by humans	A worker connected the circuit of a distribution line inappropriately. As a result, electrical equipment failed and train operations were affected.
Same as above	HMC is objective	Caused by railway facility, etc.	Train operations were affected when ground equipment was hit and damaged by lightning.
Same as above	Same as above	Caused by humans	A passenger affected train operations by tampering with ground equipment, causing its failure.
Urban railway transportation-related problems	HMC is subjective		Train operations were affected when a proceed indicator disappeared due to the failure of a signal data transmitter.
Same as above	HMC is objective		Train operations were affected when the power supply to HMC was stopped due to a power failure at a Electric power company.
Accident			Passengers were locked in an elevator car for 30 minutes due to an elevator failure.
Accident			An automatic ticket checker failed soon after it was repaired due to looseness of attached parts.
Accident			While inspecting a high-voltage cable, a staff suffered a serious injury due to an electric shock.
Accident			Part of the station building was flooded because a pump could not completely drain flood water due to heavy rain.
Accident			While patrolling during a rain storm, a staff member was injured after being blown by strong winds from the platform onto to the railway track.
Near accident case			Although a distribution line was inappropriately connected, train operations were not affected because the current was automatically cut off at the breaker and a spare circuit was formed.
Near accident case			Although the staff member forgot to cut off the power to the circuit being checked before inspecting a high-voltage cable, he avoided being injured because he checked the voltage at the site.

B. Report Forms (Forms for reference)

Report form 1 (Italics and blue characters are description examples)

Accident and Disaster Report (Prompt report)

Date created	*2017.8.2*	*Line 2A Signal and Communication Inspection and Repair Center*
Date and time of occurrence	*(Date) (2017.1.8)* *Time: 10:15*	
Site of occurrence	*Line 2A Ha Dong Station*	
Description of accident	*Failure of signal device (inbound line No.1 Signal Indication stopped)*	
Duration of operation-related problems	*33 minutes [Duration of operation-related problems of train operations (10:15 to 10:48)]*	
Concerned personnel	*[When the accident resulted from a mistake during an inspection, input the worker's name, age, years of experience, etc.]*	
Cause	*Failure on signal data transmitter*	
Treatment	*Replacement with a product in storage*	
Emergency measures	*Extraordinary inspection of every signal data transmitter at Ha Dong Station*	
Time series	*10:15 Alarm sounded indicating failure of signal device at Ha Dong Station. (Alarm was output to OCC and Line 2A Signal and Communication Inspection and Repair Center)* *10:16 Driver of an inbound train parking at Ha Dong Station reported to OCC that indication of No.1 signal remains stopped.* *10:16 Engineer A, Leader B and Worker C were dispatched from Line 2A Signal and Communication Inspection and Repair Center to Ha Dong Station.* *10:20 Ha Dong Station staff began inspection inside the track.* *10:35 Ha Dong Station reported to OCC that no abnormalities were detected on the track.* *10:40 OCC instructed Ha Dong Station to resume train operations by use of station staff hand signals.* *10:48 Operations were resumed with hand signals.* *10:52 A, B and C arrived at Ha Dong Station and started inspection (a report to this effect was made to Ha Dong Station, OCC and Line 2A Signal and Communication Inspection and Repair Center).* *11:00 They detected a failure of signal data transmitter of the inbound line signal No.1 in signal room of Ha Dong Station.*	

	11:15 They replaced failed equipment with other equipment in storage and successfully restored normal operations. *11:16 They reported to Ha Dong Station and OCC that normal operations had been restored (a report to this effect was also made to Line 2A Signal and Communication Inspection and Repair Center).* *11:25 Operations based on signal device was resumed.*

Report form 2 (Italics and blue characters are description examples)

2017.8.7

Line 2A Signal and Communication Inspection and Repair Center

Accident and Disaster Report (Interim report)

1. Date of occurrence *2017.8.1 Tue 10:15*
2. Site of occurrence *Line 2A Ha Dong Station*
3. Description of accident *Failure of signal device (inbound line No.1 Signal Indication stopped)*
4. Duration of operation-related problems *33 minutes*
5. Concerned personnel *None special*
6. Outline

10:15 Alarm sounded indicating failure of signal device of Ha Dong Station. It was confirmed that indication of the inbound line signal No.1 was stopped. Station staff began checking inside the track and dispatch of Signal and Communication Inspection and Repair Center staff was started. Since no abnormalities were detected by station staff, hand signal-based operations were resumed at 10:48. At around this time, staff of Signal and Communication Inspection and Repair Center arrived and began inspection.

Inspection by staff of Signal and Communication Inspection and Repair Center detected failure of signal data transmitter of the inbound line No.1 signal. They replaced failed equipment with other equipment in storage and successfully restored normal operations. 11:25 Operations based on signal device were resumed.

7. Cause, Treatment and Problem Area

The cause was a failure on signal data transmitter. They replaced failed equipment with other equipment in storage and successfully restored normal operations.

Inspection of multiple the signal data transmitters in signal equipment room of Ha Dong Station found that their output power was declining.

8. Emergency Countermeasures and Results of their Implementation

An extraordinary inspection (measurement of output power) was conducted on every signal data transmitter at Ha Dong Station

An extraordinary inspection detected three transmitters with output power lower than the tolerance. The Center staff adjusted output power of these three transmitters to be closer to the tolerance.

9. Provisional Measures

An extraordinary inspection (output power measurement) is going to be conducted within a month from today on every signal data transmitter of every Line 2A station. Any item of equipment with output power lower than the tolerance shall be adjusted to the tolerance.

10. Permanent Measures

(Contents shall be outlined.)

11. Time series

(Contents shall be outlined.)

12. Remarks

(Data obtained in last inspection, etc.)

Report form 3 (Blue characters are description examples)

2017.8.13

Line 2A Signal and Communication Inspection and Repair Center

Accident and Disaster Report (Final report)

1. Date of occurrence *2017.8.1 Tue 10:15*
2. Site of occurrence *Line 2A Ha Dong Station*
3. Description of accident *Failure of signal device (inbound line No.1 Signal Indication stopped)*
4. Duration of operation-related problems *33 minutes*
5. Concerned personnel *None special*
6. Outline

   (Contents shall be outlined.)
7. Cause, Treatment and Problem Area

   (Contents shall be outlined.)
8. Emergency Countermeasures and Results of their Implementation

   (Contents shall be outlined.)
9. Provisional Measures and Results of their Implementation

An extraordinary inspection (output power measurement) is taking place on signal data transmitter of every Line 2A station. The staff are adjusting output power of equipment when it is lower than the tolerance.

Currently measurement has been completed at __ stations out of total __ stations, and no abnormalities have been detected at any station other than Ha Dong Station.

10. Permanent Measures

Equipment on which low output power was detected during an extraordinary inspection shall be replaced with new ones.

11. Time series

    (Contents shall be outlined.)
12. Remarks

    (Data obtained in last inspection, etc.)

Report form 4 (Italics and blue characters are description examples)

<u>Report on Railway Operation Accident and Others</u>

<table>
<tr><td rowspan="2">To......................</td><td>Name of business operator</td><td>Hanoi Metro Company</td></tr>
<tr><td>Date submitted</td><td>2017.8.1</td></tr>
<tr><td>Date and time of occurrence</td><td colspan="2">Date of occurrence 2017.8.1 Tue 10:15</td></tr>
<tr><td>Type of accident</td><td colspan="2">Transportation-related problems</td></tr>
<tr><td>Place</td><td colspan="2">○○ Line Between ○○ Station and ○○ Station Inbound line ○○k○○m spot</td></tr>
<tr><td>Train</td><td colspan="2">A○○ Local train 6 cars</td></tr>
<tr><td>Casualty figure</td><td colspan="2">None</td></tr>
<tr><td>Problem on main line</td><td colspan="2">Operation resumed: 2017.8.1 Tue 10:48, Duration of operation-related problems: 33 minutes</td></tr>
<tr><td>Number of trains affected</td><td colspan="2">Number of canceled trains3 and number of delayed trains 20</td></tr>
<tr><td>Amount of damage</td><td colspan="2">(Respective costs ...)</td></tr>
<tr><td>Concerned personnel</td><td colspan="2">None</td></tr>
<tr><td>Cause</td><td colspan="2">Failure on signal data transmitter</td></tr>
<tr><td>Recurrence prevention measures</td><td colspan="2">An extraordinary inspection of every signal data transmitter at Ha Dong Station and related treatment (details are being studied).</td></tr>
<tr><td colspan="3"><u>Overall Condition</u>
10:15 An alarm sounded indicating failure of signal device of ___ Station. It was confirmed that indication of the inbound line signal No.1 was stopped. Station staff began checking inside the track and dispatch of Signal and Communication Inspection and Repair Center staff was started. Since no abnormalities were detected by station staff, hand signal-based operations were resumed at 10:48. At around this time, staff of Signal and Communication Inspection and Repair Center arrived and began inspection.
Inspection by staff of Signal and Communication Inspection and Repair Center detected failure of signal data transmitter of the inbound line No.1 signal. They replaced failed equipment with other equipment in storage and successfully restored normal operations. 11:25 Operations based on signal device were resumed.</td></tr>
</table>

JICA-Supported Project of Reinforcement of Urban Railway Regulatory Agency and Establishment of Operating Company in the City of Hanoi

Materials:

Draft of Equipment maintenance manual 〈Line 2A communication equipment〉

Implementer: **Nguyen Viet Quan**

JICA TA Team: Mr Takeshi Ikeda

November 30, 2015 in Hanoi

Contents

2. Monthly Maintenance Plan (Form)

3. Long-term Maintenance Plan (Form)

4. Budget Planning (Form)

F: Acceptance Inspection, Quality Evaluation and Monitoring after Work

G: Implementing Organization

1. Organizational Structure

2. Responsibility for Implementation

3. Revision and Additions

Attached Reference Materials

1. **Organizational Structure, Functions and Assignment of Maintenance Section at Headquarters (HQ) and in Field (OU)**
2. **Procedure for Calculating Necessary Number of OU Staff**
3. **Procedure for Calculating Costs of Required Maintenance Items (Including the guideline for creating the list of items that are to be managed in-house and the list of items to be outsourced)**
4. **Procedure for Creating Operational Plan relevant to Maintenance Work (Including the forms of the business plan and the update plan to be developed)**
5. **Guideline for Creating Staff Training and Education Plan**
6. **Criteria for Number of Units Installed**
7. **Provisions on Information Sharing**
8. **Guideline and Form for Creating Equipment Ledger**
9. **Ledger Form of Equipment Durable Years**

A: Legal Foundation

1. Laws and Regulations

- Vietnam Railway Act 2005:

- Contents of this regulation shall be compliant with the laws and regulations of Vietnam. Currently, regulations and standards concerning operation and maintenance of the urban railway are being prepared in Vietnam. After the above regulations and standards are officially announced, we must update and recreate our regulations in order to comply with them.

2. Relevant Materials

- Circular No. 20/2013/TT-BGTVT dated 2013/8/16 on Management and Maintenance of Railway Structure.
- Circular No. 05/2015/TT-BGTVT dated 2015/3/30 on Standard for Operating Staff of Urban Railway.
- Circular No. 52/2014/TT-BCA on Management, Storage and Maintenance of Fire Extinguishing Means.
- Circular No. 07/2014/TT-BLĐTBXH on Announcement of Technological Safety Verification Process 27 of Machines and Equipment that are under the jurisdiction the Ministry of Labor, Disabled Veterans and Society, and are required to satisfy stringent safety requirements.
- Circular No.21/2015/TT-BGTVT on Working Hours and Break Time of Employees Who Engage in Specific Operations in Railway Transportation.
- Standard QCVN No. 06:2011/BGTVT on Railway Signals.
- Standard QCVN No. 08:2015/BGTVT on Railway Operation.

Standard QCVN No. 09:2010/BTTTT on Earth Connection at Communication Site.

- TCVN No. 8585:2011 on Urban Railway for Fast and Mass Transit

Basic Standard TCCS No.01:2009/VNRA on Design, Construction and Acceptance Inspection of Railway Signal Communication Construction

- General Railway Structure Maintenance Standard TCCS No. 02:2014/VNRA
- Seamless Railway Structure Maintenance Standard TCCS No. 03:2014/VNRA

Standard TCCS No.05:2014/VNRA on Goods, Materials and Accessory Products used for Railway Maintenance Work.

- Railway Communication Facility Maintenance Standard TCCS No.08:2014/VNRA
- Railway Signal Facility Maintenance Standard TCCS No.09:2014/VNRA

Standard TCCS No.10:2014/VNRA on Goods, Materials, Equipment and Parts used for Railway Signal Communication Maintenance Work.

- Specifications provided by equipment provider/contractor
- Technology design for the Line 2A (Cat Linh-Ha Dong) Equipment (Chinese consultant)
- Technology Design for Line 3 (Nhon-Ha Noi Station) Equipment (A French consultant)
- Technology Design for Line 2 (Nam Thang Long-Tran Hung Dao) Equipment (A Japanese consultant)
- Other Reference Material from TA Project
- Training Plan Ver 16.0 for the Line 2A (Cat Linh-Ha Dong)

3. Purpose

The Communication Equipment Maintenance Manual has been established in order to maintain the technical standard related to the equipment and also to help ensure stable operation of the electric power equipment by making sure that the maintenance staff's work practices and procedures are consistent with the regulations.

4. Definition of Terms and Interpretation of Abbreviations

4.1. Definition of Terms

The term equipment denotes the communication equipment, signal equipment, electric power equipment and station equipment.

Communication equipment is the provision used to ensure safe operation and provide communication for passenger service.

Signal equipment consists of the interlocking device and the signal system that controls trains for the safe operation.

Electric power equipment is the provision that supplies power from a distribution board to each station's equipment and power to trains for travel from an electric power substation.

The electric room of a station is the room containing equipment that supplies power to station equipment.

The electric room of a depot is the room containing equipment that supplies power to depot equipment..

Station equipment refers to the equipment in a station that utilizes electricity excluding AFC equipment, communication equipment and signal equipment.

Equipment maintenance refers to work processes necessary to ensure and maintain normal operations of equipment as specified in the course of business transactions. Equipment maintenance work includes inspections, maintenance, repairs and quality verification of equipment.

Inspection means identifying the condition of equipment either by using intuition or by use of specialized tools in order to identify a failure or potential failure, and requesting recovery-related actions when a failure is detected.

Periodic inspections involve inspecting each item of equipment based on the cycle specified for them in order to maintain them in normal condition up to the next inspection.

Extraordinary inspection refers to an inspection other than the periodic inspection that takes place as needed in the wake of an accident, equipment modification or disaster.

Maintenance denotes the activities of monitoring, maintaining and repairing equipment on a continual or regular basis in order to ensure normal operation of each item of equipment and to reduce potential failures.

Repair is the activity of fixing failures that have occurred in the course of equipment operation to ensure safe railway operations. Repair comprises both periodic and extraordinary repair work.

Periodic repair refers to replacement of a section or part, or adjustment that is carried out on a regular basis according to the specified troubleshooting or maintenance procedure of each item of equipment.

Extraordinary repairs are carried out when a safe rail transportation is affected by an accident, transportation-related problem, disaster, etc.

Design quality validation inspects and validates the quality, and evaluates compliance of the given item of equipment with the relevant design requirements.

Maintenance staff denotes the Manager, Deputy Manager, Section Engineers, Leaders and workers at the Center.

The maintenance plan is a table that summarizes necessary maintenance work processes being planned in chronological order. The maintenance plan comprises the inspection plan, maintenance plan, repair plan and budget plan.

Patrol is the work of identifying environmental changes as well as the condition of equipment installed in a particular location that requires maintenance to help ensure equipment is managed appropriately and accidents are prevented.

The Equipment Inspection Standard Table contains the inspection items indispensable in the periodic inspection.

The Inspection Base Date refers to the day designated for the periodic inspection.

The Inspection Base Date Control Table is used to control the inspection base date for every item of equipment.

The Periodic Inspection Roadmap is a table that summarizes the longest inspection cycle set for each item of equipment in the equipment inspection standard table.

Monthly Workload Planning shows the maintenance work of a month in a table form.

Annual Workload Planning shows the maintenance work of a year in a table form.

Long-term Workload Planning shows the multi-year maintenance work in a table form.

Inspection Table is used to record results of the equipment inspection.

Work Instructions provide instructions necessary during equipment maintenance.

The operating Report is used to report the result of the completed equipment maintenance.

Equipment Maintenance Manual describes the procedures, precautions, manual work procedures, operation method, etc. necessary to carry out the equipment maintenance.

4.2 Abbreviations

HQ: Headquarters

OU (Operation Unit): Local companies

BGTVT: Ministry of Traffic and Transportation

BCA: Ministry of Public Safety

BCT: Ministry of Industry and Commerce

BLĐTBXH: Ministry of Industrial Injury and Society

ĐSĐT: Urban railway

QCVN: National Technical Criteria

TCVN: National Technical Standard

TCCS: Base Criteria

QTKĐ: Verification process

ATC: Automatic Train Control

ATO: Automatic Train Operation

ATS: Automatic Train Supervision

ATP: Automatic Train Protection

PAS: Public Address Systems

AWS: Automatic Warning System

....

5. List of Communication Equipment

B: Requirements for Maintenance Facilities, Equipment and Staff

1. Requirements for Facilities and Equipment

1.1. Requirements for Facilities

Create a list of the maintenance facilities, devices and tools used to implement the maintenance process based on the specification, tools and devices of the communication equipment. The above list becomes the basis of future maintenance work.

List of Facilities, Tools and Devices used for Maintenance of Communication Equipment

Order	**Device name**	**Standard or specification**	**Intended purpose**	**Note**
1				
2				

1.2. Requirements for Equipment

Decide on the equipment specifications for future repair and maintenance based on the specifications of equipment providers.

Communication Equipment Specification Table

Order	System names	Accessory equipment	Specification	Note
1	Wireless device	*As per equipment provider*	*As per equipment provider*	
2	Telephone equipment for business use	*As per equipment provider*	*As per equipment provider*	
3	Electric clock system	*As per equipment provider*	*As per equipment provider*	
4	Security camera system	*As per equipment provider*	*As per equipment provider*	
5	Announcement system	*As per equipment provider*	*As per equipment provider*	
6	Passenger guiding system	*As per equipment provider*	*As per equipment provider*	
7	Communication system at depots	*As per equipment provider*	*As per equipment provider*	
8	....			

- Spare equipment shall be stored in a separate location. Their quantity and quality shall be warranted for use as needed.

1.3. Requirements for Maintenance Tools and Devices

- Maintenance tools, devices and facilities must be kept in good condition at all times.
- Special equipment for emergency purposes must be kept in a separate location, and clear indicative information and appropriate guidance must be attached.

2. Requirements for Staff

2.1. Requirements for Number of Maintenance Staff

(How to calculate the number of necessary staff at HQ and OU based on the Line 2A education plan and the reference materials used in the TA project.)

2.1.1. How to calculate the number of No.2A staff

a. Number of managerial staff

- The number depends on the workload and administrative abilities.
+ Managerial staff may directly carry out maintenance work.
+ In order to ensure quality of the maintenance work, managerial staff other than the Manager should carry out the work in three shifts.
+ Manager and Deputy Manager must support Section Engineers in implementing the maintenance work.
- Should be determined based on the workload.
- The number should be determined based on the maintenance plan developed.

➔When Line 2A began operations, six managerial staff were assigned for management and implementation of maintenance work. On each of the staff was assigned as the Manager (also serves as the person in charge of signal), the Deputy Manager and Section Engineer.

b. Number of workers

- The number depends on the equipment maintenance workload.
- The number of each group represents the average number computed on the assumption that each has necessary capabilities to carry out the work.
- Holidays and sick leave taken by maintenance staff must be taken into consideration.
- A total of 18 maintenance staff engage in maintenance of the communication equipment (railway radio, telephones, switching equipment, announcement system, automatic passenger guiding system, communication system, communication line, security TV system, electric clock, station fire-prevention monitoring device, etc.) (1.5 people/station according to the standard of Beijing Railway). There are 12 stations along the Line 2A. Two groups are set up. Nine staff are assigned to each group. One of them is the Leader and eight are workers. One group covers maintenance work of 6 stations. They carry out maintenance on a 3-shift system according to the shift roster set by the Manager of OU.

2.1.2. For reference when calculating the number of other staff

- The HQ and OU staff number calculation method and shift roster developed by the specialist in the TA project and C/P (See the attached material).

2.2. Requirements for Capacity and Skill Level of each Duty Position at Inspection and Repair Center

2.2.1. The Center Manager assumes total responsibility for all operations performed at the Center, and is responsible for providing guidance to Center employees to ensure they implement the allotted assignments.

The Manager is responsible for all operations including those related to safety, service, emergency inspections and repairs, as well as cultural establishment. Therefore, the Manager of the Signal and Communication Equipment Inspection and Repair Center must meet the following requirements.

- Has a college education or above, and expert knowledge in signal and communication equipment management.
- Has more than three years experience in signal and communication equipment management.
- Is knowledgeable in the applicable laws and regulations, and complies with the rules of the organization.
- Has the ability to improve oneself via study, a good imagination, and the ability to be diplomatic when negotiating. - Has sufficient decision-making abilities.
- Has a certificate of health proving that they satisfy the health standard set by the Ministry of Medical Services.

2.2.2. The Deputy Manager in charge of communication at OU shall assist the Manager in executing the Center's operations and assume the responsibility for managing the communication equipment. Therefore, the Deputy Manager of the Signal and Communication Equipment Inspection and Repair Center must meet the following requirements.

- Has a college education or above, and expert knowledge in communication equipment management.
- Has more than two years experience in signal and communication equipment management.
- Is knowledgeable in the applicable laws and regulations, and complies with the rules of the organization.
- Has the ability to improve oneself via study, a good imagination, and the ability to be diplomatic when negotiating.

2.2.3. The Deputy Manager in charge of signal at OU shall assist the Manager in executing the Center's operations and assume the responsibility for managing the signal equipment. Therefore, the Deputy Manager of the Signal and Communication Equipment Inspection and Repair Center must meet the following requirements.

- Has a college education or above, and expert knowledge in signal equipment management.
- Has more than two years of experience in the signal equipment management.
- Is knowledgeable in the applicable laws and regulations, and complies with the rules of the organization.
- Has the ability to improve oneself via study, a good imagination, and the ability to be diplomatic when negotiating.

2.2.4. The Signal Section Engineer must manage technology related to the signal equipment, manage failures and implement recovery measures in urgent situations. Therefore, the Signal Section Engineer must meet the following requirements.

- Has a college education or above
- Has expert knowledge about principles of the signal equipment system, understands the technical processes, technical standard and recovery measures in the case of urgent accidents, and a high degree of skill in handing software for office use as well as sophisticated special software such as CAD.

- Has the ability to improve oneself via study, a good imagination, and the ability to be diplomatic when negotiating.

2.2.5. The Communication Section Engineer must manage technology related to the communication equipment, manage failures and implement recovery measures in urgent situations. Therefore, the Communication Section Engineer must meet the following requirements.

- Has a college education or above
- Has an expert knowledge about the principle of the communication equipment system, understands the technical processes, technical standard and recovery measures in the case of urgent accidents, and a high degree of skill in handing software for office use as well as sophisticated special software such as CAD.
- Has the ability to improve oneself via study, a good imagination, and the ability to be diplomatic when negotiating.

2.2.6. The signal equipment maintenance worker is responsible for maintaining the signal equipment according to the rules and procedures specified by the company, and rescuing others urgently and directly should an accident or failure occur. Therefore, the signal equipment maintenance worker must meet the following requirements.

- Has a high school education or above
- Has special knowledge, a qualification or a maintenance-related certificate for the signal equipment.
- Has the ability to improve oneself via study, a good imagination, and complies with organization rules.

2.2.7. Communication equipment maintenance workers are responsible for maintaining the communication equipment according to the rules and procedures specified by the company, and rescuing others urgently and directly should an accident or failure occur. Therefore, the communication equipment maintenance worker must meet the following requirements.

- Has a high school education or above
- Has special knowledge, a qualification or a maintenance-related certificate for the communication equipment.
- Has the ability to improve oneself via study, a good imagination, and complies with organization rules.

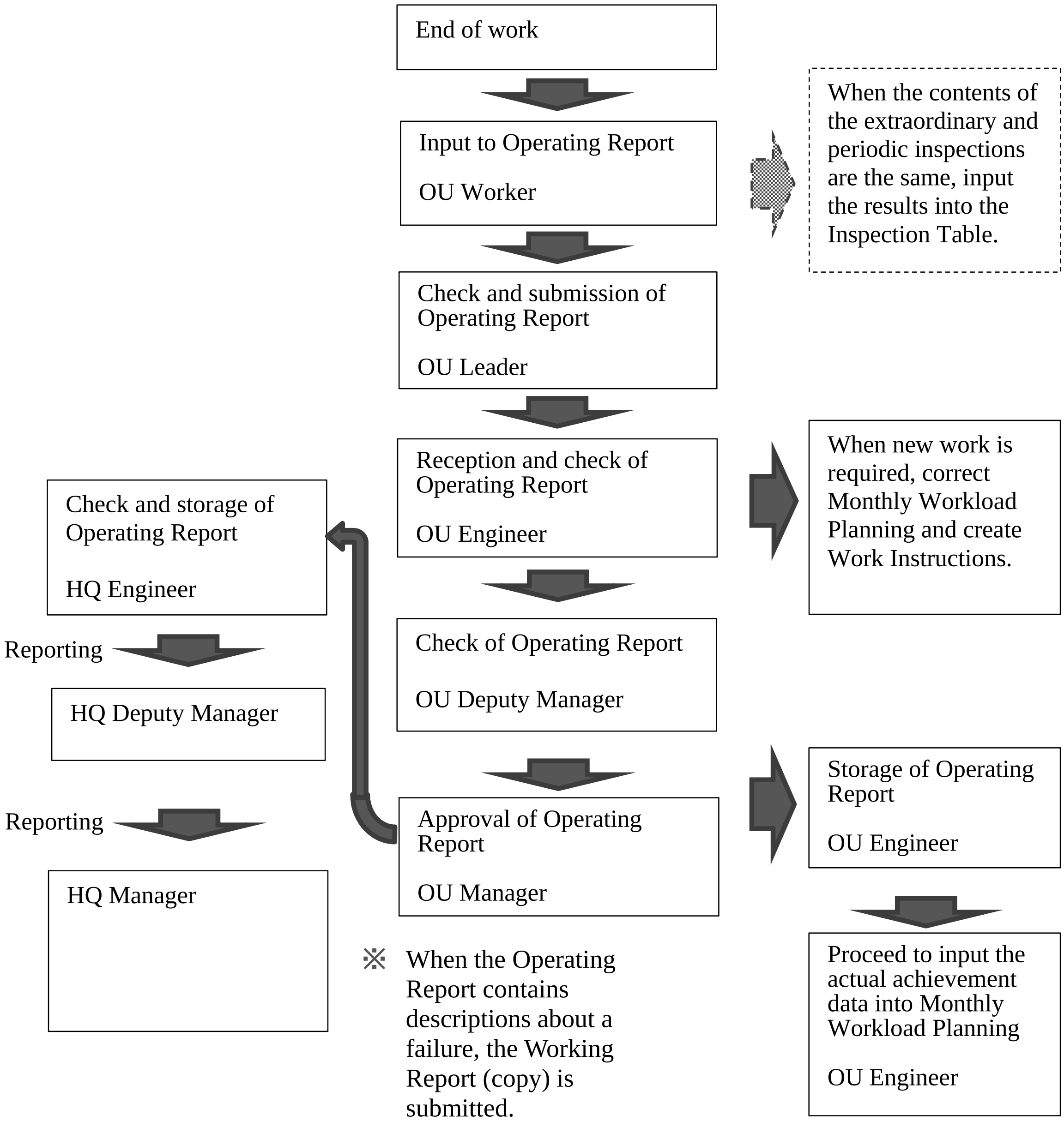
C: Classification of Maintenance Operations and Work Implementation Flow

1. Classification of Maintenance Operations

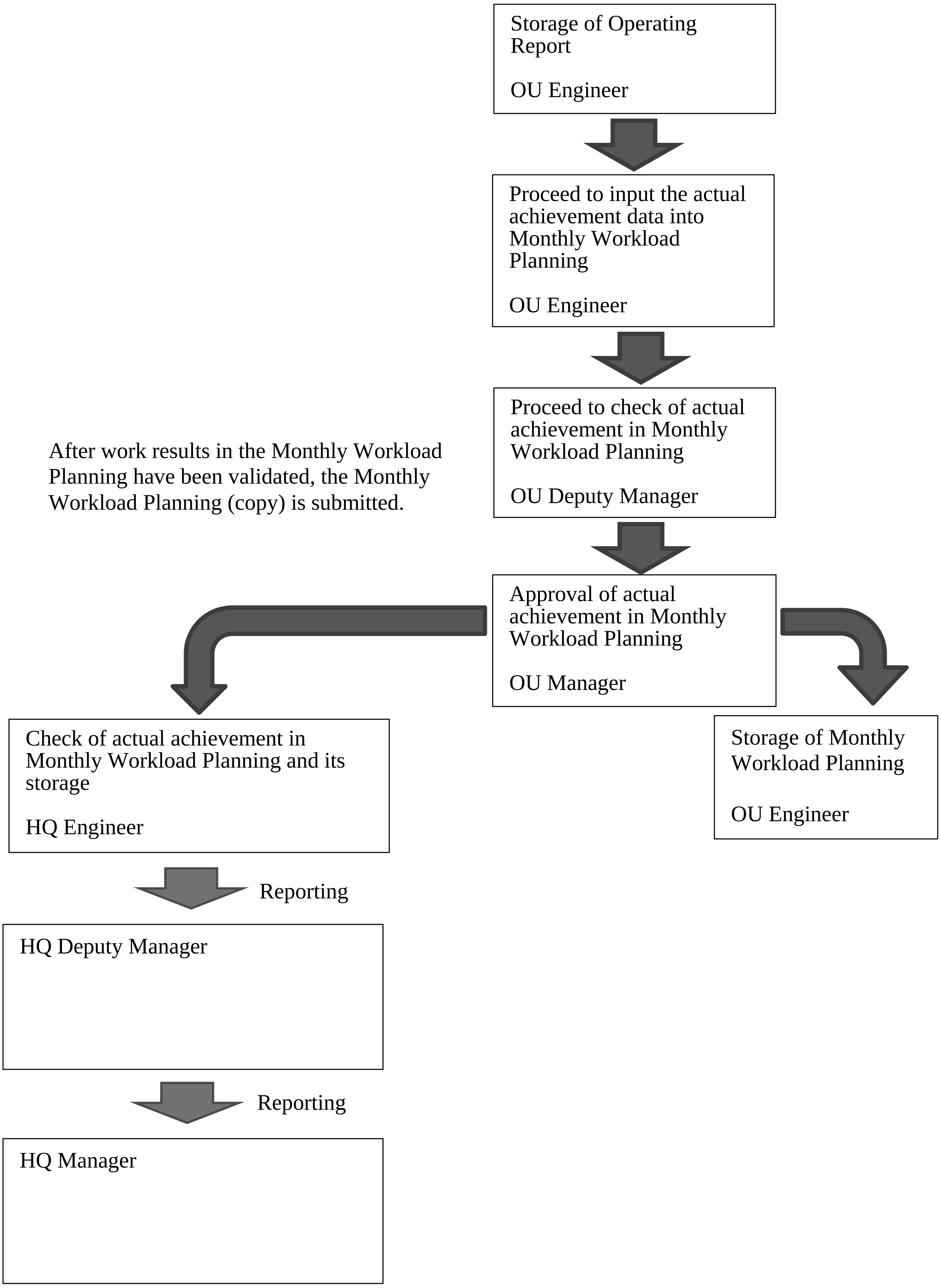
- Equipment maintenance work must include the inspection, maintenance, repairs and quality verification of the equipment.
- The equipment inspection must include a periodic inspection and an extraordinary inspection. The equipment inspection must include an overall inspection and a detailed inspection.
- Equipment repair work must include periodic repairs and extraordinary repairs.

2. Work Implementation Flow

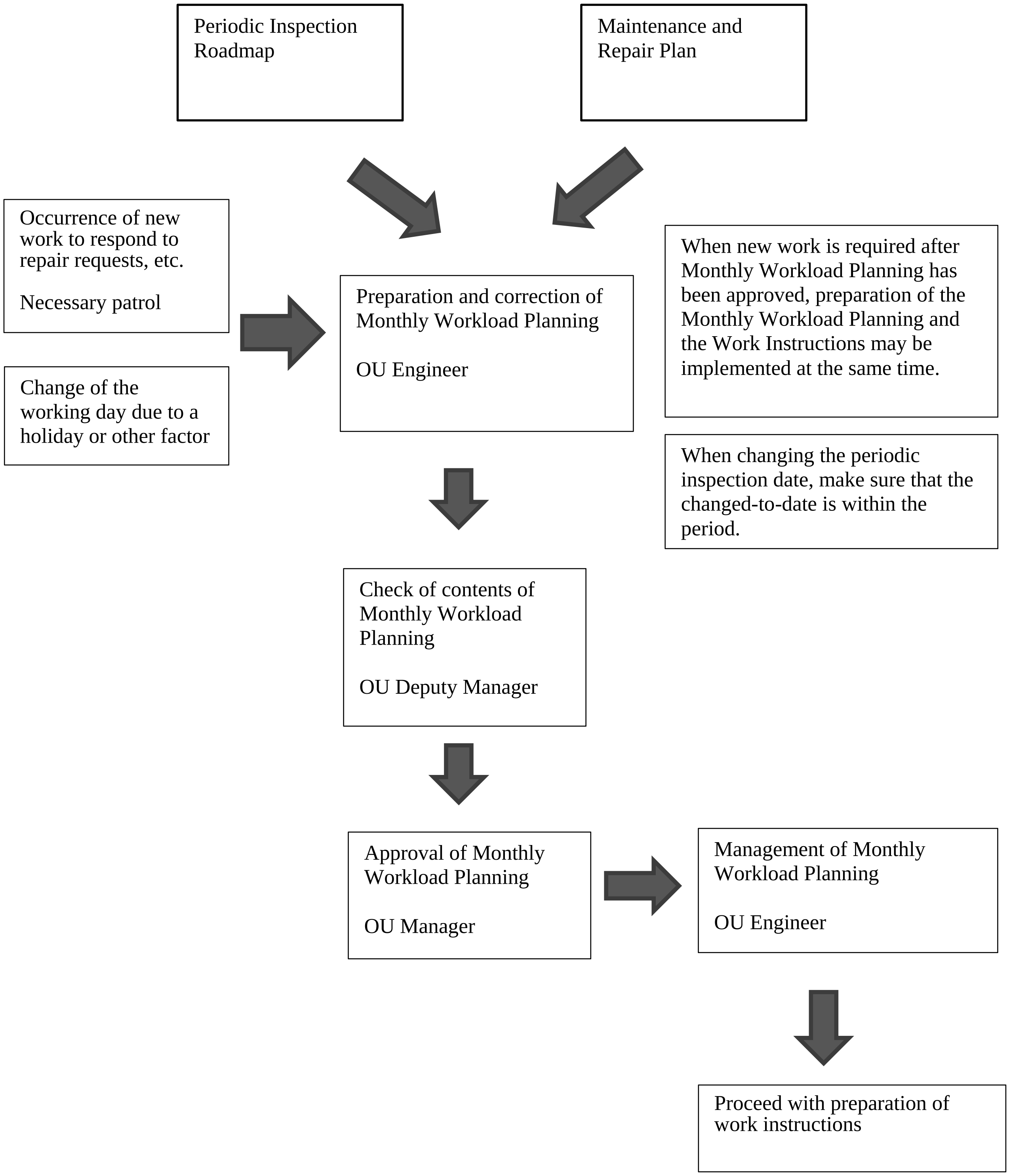
2.1. Operating Report Preparation Flow



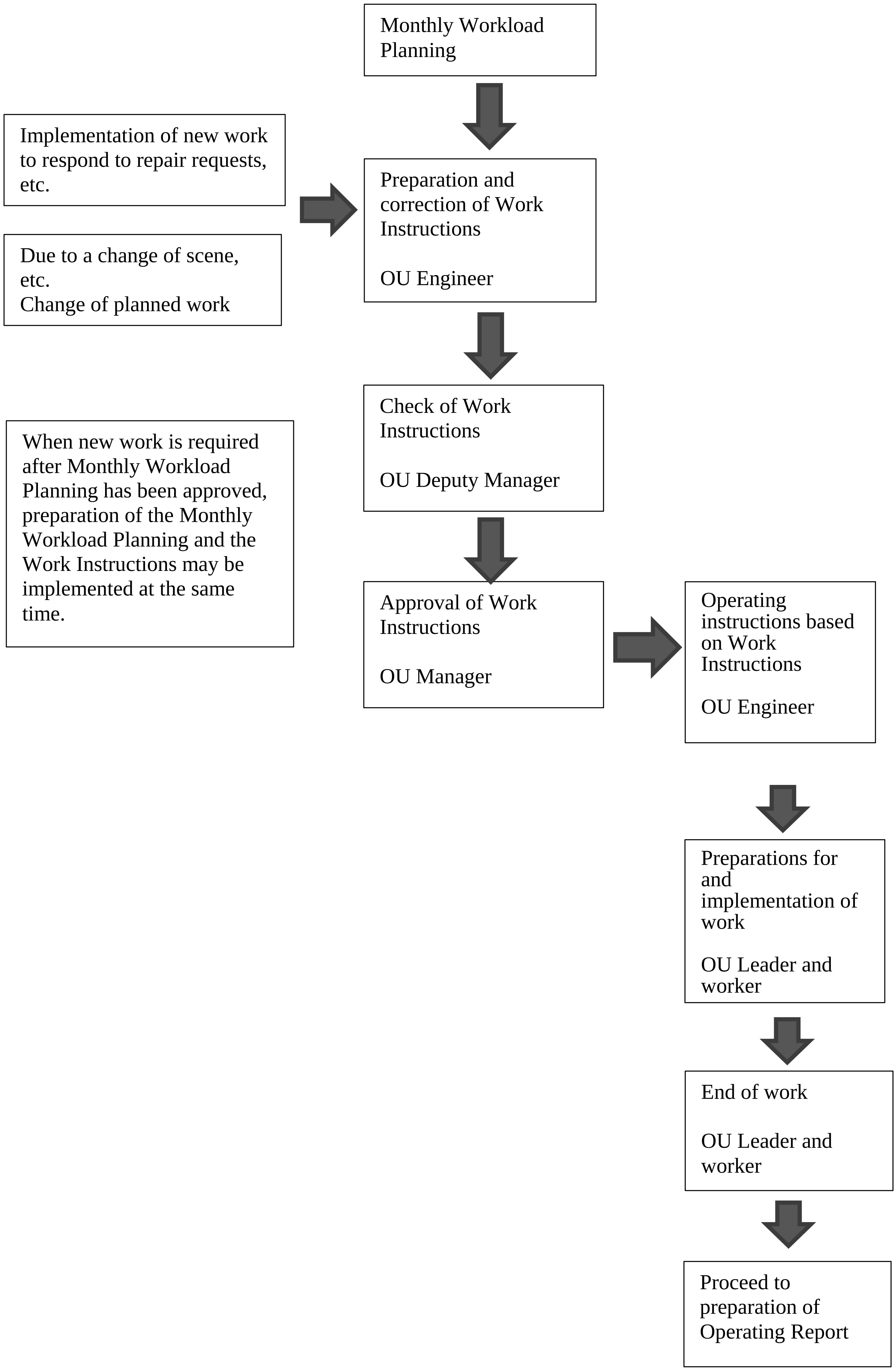
2.2. Flow of Entry of Actual Achievement to Monthly Workload Planning



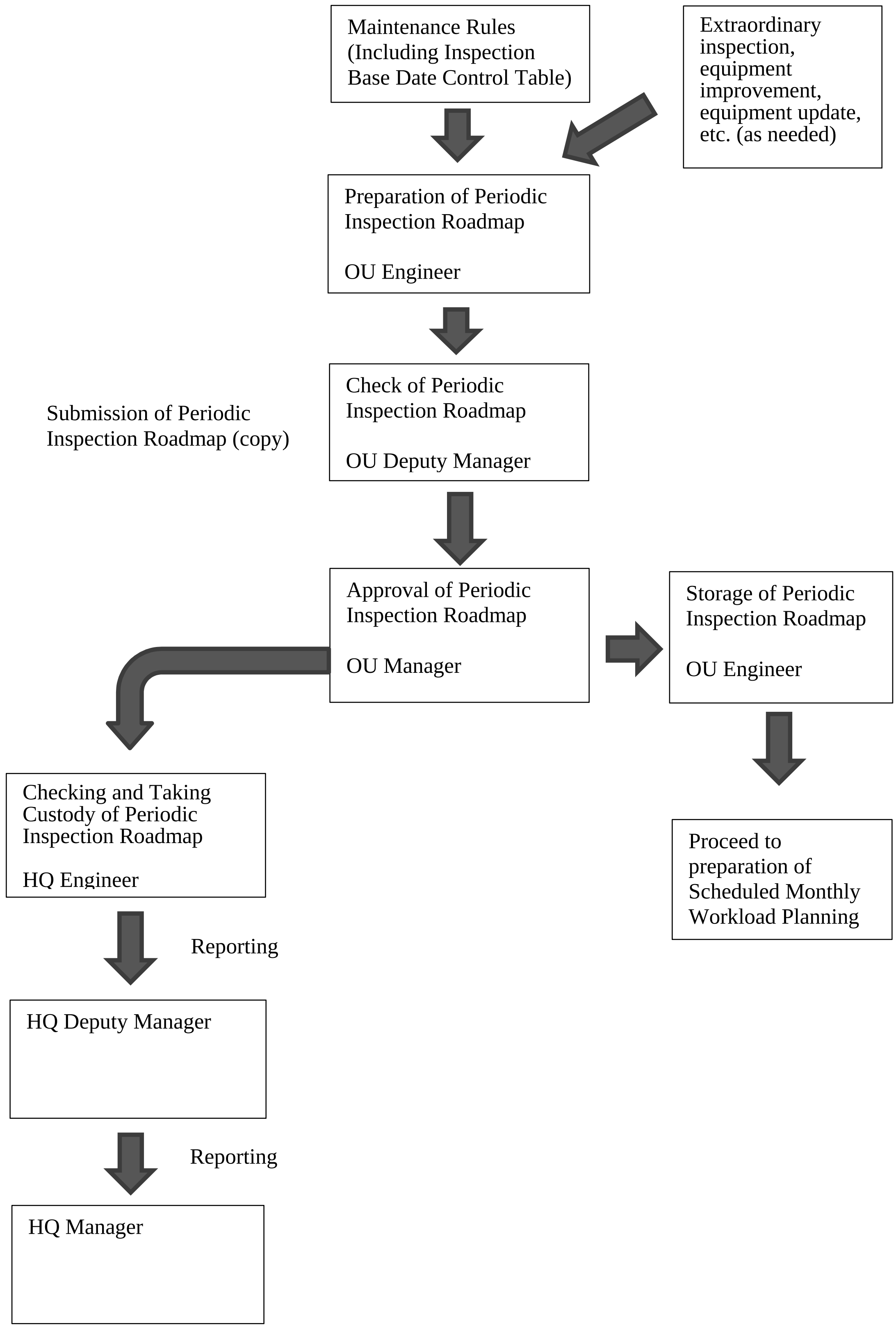
2.3. Monthly Workload Planning Preparation Flow



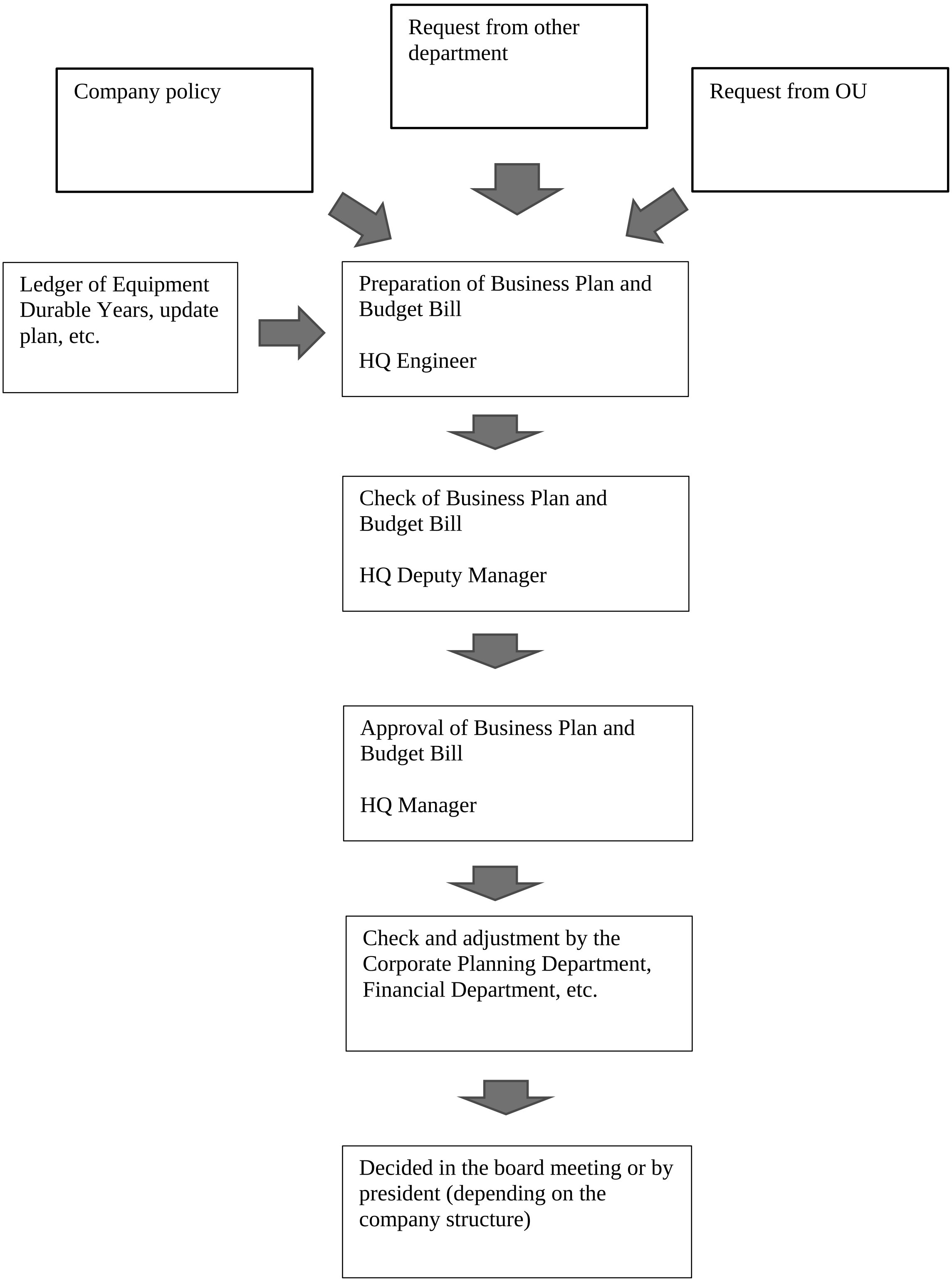
2.4. Work Instructions Preparation Flow



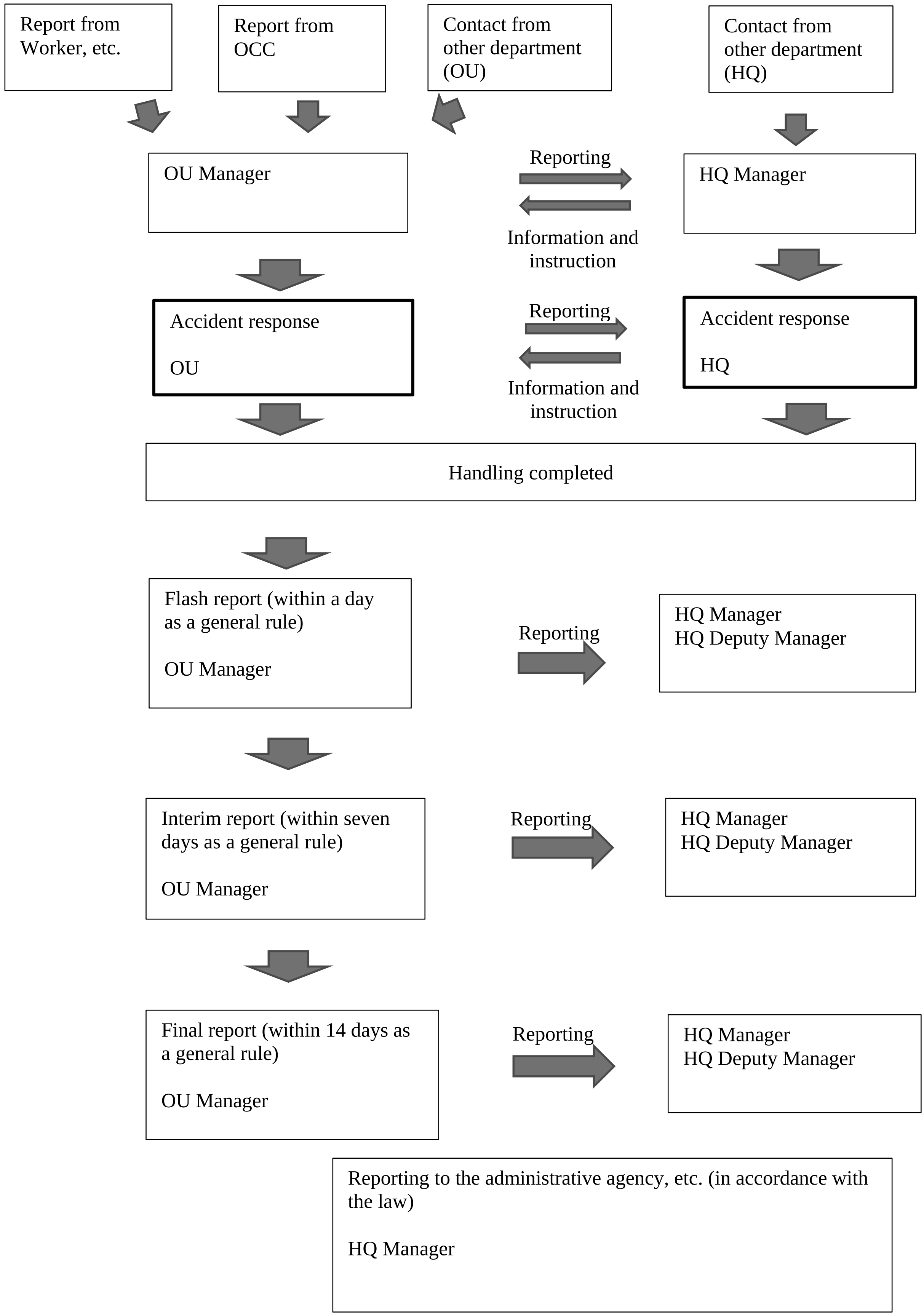
2.5. Periodic Inspection Roadmap (Long Term) Preparation Flow



2.6. Business Plan and Budget Preparation Flow



2.7. Flow of Response to Accidents and Transport Disorders



D: Survey Measurement and Validation of Equipment Condition

1. Installation Location

- Inspect appropriateness of the equipment referencing the working and design drawings.
- Be sure to inspect and measure the installation location based on the provisions and procedures described in the approved Work Instructions.

2. Validation of Equipment Operating Status

2.1. Overall Inspection of Equipment

- Acceptability of the operating status
- Acceptability of the installed condition
- Check whether a problem resulted from environment, weather, etc.
- Check presence or absence of stains, damages, etc.
- Check presence or absence of abnormal odors, noises, etc.

2.2. Detailed Equipment Inspection

Order	System names	Contents of inspection *(For reference only)*	Inspection cycle	Note
1	Train wireless device	1. Device body (each communication equipment room, field and equipment of OCC) Acceptability of wiring and mechanism 2. General function (1) Acceptability of function and control Acceptability of acoustic quality, alarm activation, etc. (2) Suitability of transmission and reception level (3) Acceptability of interface with relevant equipment (4) Suitability of spurious level (level of unnecessary radio wave)		
2	Telephone equipment for business use	1. Telephone switchboard body (1) Acceptability of function (2) Acceptability of wiring and mechanism 2. General function Acceptability of interface with relevant equipment	2 years	
3	Electric clock system	1. Electric clock system body (1) Acceptability of function and control - Precision of time and acceptability of time correction function (2) Acceptability of wiring and mechanism 2. General function	2 years	

		Acceptability of interface with relevant equipment		
4	Security camera system	1. For operation (Driver, conductor and station staff) Camera and monitor (1) Acceptability of function (2) Acceptability of wiring and mechanism 2. For security <stations, OCC etc.> Camera, monitor and video player (1) Acceptability of function (2) Acceptability of wiring and mechanism	1 years	
5	Announcement system	1. Device body (1) Acceptability of function and control Acceptability for announcement in real voice and siren (2) Suitability of sound pressure 2. General function Acceptability of interface with relevant equipment	1 years	
6	Passenger guiding system	1. Device body (1) Acceptability of function and control (2) Acceptability of wiring and mechanism 2. Platform indicator (1) Acceptability of function (2) Acceptability of wiring and mechanism 3. General function Acceptability of interface with relevant equipment	2 years	
7	Communication equipment at depots	1. Ground equipment for testing equipment on the vehicle side of the train radio system (simplified ground equipment) 2. Telephone equipment for professional use, entry phones, etc. 3. Security camera 4. Announcement system Others		
8	....			

E: Development of Plan (*Create the form according to the Plan Preparation Manual)*

1. Plan of the day (List the daily maintenance work items based on the monthly plan)

1.1. Work Instructions

<table>
<tr><td rowspan="2">Work Instructions</td><td rowspan="2" colspan="2">Date and time
(Work implementation time specified in the Work Instructions)

Signal and Communication Equipment Inspection and Repair Center: the Line 2A</td><td>OU Manager (Approver)</td><td>OU Deputy Manager (Checker)</td><td>OU Engineer (Preparer)</td></tr>
<tr><td>*(Signature)*</td><td>*(Signature)*</td><td>*(Signature)*</td></tr>
<tr><td>Time when a failure detected
(Describe date and time in detail)</td><td colspan="2">Year __ Month __ Day __ Hour __</td><td>Requested by

(Signature)</td><td colspan="2">Including the reason why the failure was detected
Station, alarm, periodic inspection, patrol and other</td></tr>
<tr><td>Location and equipment name</td><td colspan="2"></td><td>Work code (When provided)</td><td colspan="2"></td></tr>
<tr><td>Work name</td><td colspan="5"></td></tr>
<tr><td colspan="6">Contents of instruction (What, how, by when, current situation, drawings, etc.)</td></tr>
<tr><td colspan="6"></td></tr>
<tr><td colspan="6">Precautions for work (A special location, requirements, precautions for work)</td></tr>
<tr><td colspan="6">1</td></tr>
<tr><td colspan="6">2</td></tr>
</table>

1.2. Operating Report

Working hours	Day /Night	Materials used (To be clearly indicated in the instructions)	Available /Unavailable	Arrangement Date	Receipt of material	
Operating Report				Date repair completed	Date	Reported by (Signature of Leader)
	OU Manager			OU Deputy Manager	OU Engineer	
Confirmation of completion						

Correction of records in Inspection Table	Input to Monthly Failure Report	Correction of maintenance drawing	Correction of Equipment Ledger	Input to Shipping/Receiving Card
Yes/No/Finished	Yes/No/Finished	Yes/No/Finished	Yes/No/Finished	Yes/No/Finished

Date	Name of worker	Contents of work (Survey, Treatment, Result, Materials used, and Hand-off)	Check by OU Deputy Manager (When work of the shift is not completed)

Cause, treatment, comments	Model of removed item	Model of installed item
	Serial number of removed item	Serial number of installed item
	Date of manufacturing of removed item	Date of manufacturing of installed item
	Name of manufacturer of removed item	Name of manufacturer of installed item

Necessity for request of special repair (When approval of HQ Station Equipment Section is necessary)	Necessary / Not necessary

2. Monthly Maintenance Plan (Form)

Revision history			**Year _ Month _ Workload Planning** **Department: Signal and Communication Equipment Inspection and Repair Center**			Hanoi Metro Company The Line 2A		
						Plan (Signature)	Actual achievement (Signature)	Note
Day	Month	Contents of inspection			Location of inspection			<On Addition of and Change in Work> (1) When there was an addition or change in the scheduled work, describe it in the table using a pencil. (2) When an addition work is completed, indicate it using a red pencil. Connect the work before and after it with an arrow. (3) Select the applicable reason for the change from the following and write its number near the arrow. "List of reasons of addition or change" 1. Because of a change in the
		Shift 1	Shift 2	Shift 3				
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								
13								
14								
15								

<table>
<tr><td>....</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td rowspan="3">working schedule due to a holiday or other factors.
2. Because of the influence of an addition or change in other work.
3. Because of an accident or disaster.
4. Because of the convenience of the business partner.
5. Because of addition of all-night feed
6. Because of equipment failure.
7. Because of an extraordinary inspection due to equipment failure or other factor.
8. Because the work was added after the scheduled job was completed.
9. Other reason (Describe it clearly and in an easy-to-understand manner)
<On actual achievement of work>
(1) When the scheduled work was implemented, affix a “Completed” seal next to the end of the name of the work.
(2) When work that was added or</td></tr>
<tr><td>30</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>31</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table>

								changed is completed, affix a “Completed” seal to the portion furnished with rubrics after the change.

3. Long-term Maintenance Plan (Form)

Sheet number /Total number of sheets	**Periodic Maintenance Plan** **Department: Signal and Communication Equipment Inspection and Repair Center**					Hanoi Metro Company Route: 2A												
Maintenance type	Equipment name	Contents of inspection	Inspection code	Inspection period	Location of inspection	(Year)												(Year)
						January	February	March	April	May	June	July	August	September	October	November	December	
Inspection																		
......																		
Maintenance																		
....																		
Repair																		
......																		

- Long-term Maintenance Plan may be created for the periods of one year, five years, 10 years and 30 years.

4. Budget Planning (Form)

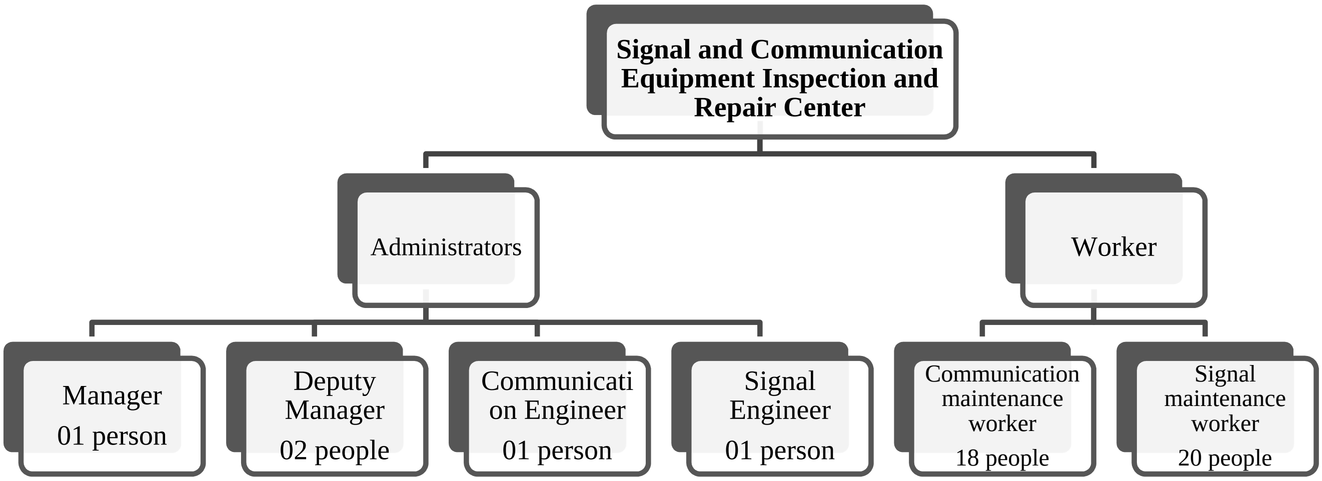
Maintenance Budget Planning - Year __									
Department: Communication Equipment Center									
Sheet number/Total number of sheets			Route: the Line 2A						
Maintenance time		**Contents of work**	**Method of implementation**	**Equipment use period**	**Maintenance cycle**	**Durable years**	**Total implementation cost**	**Cost breakdown**	**Note**
Month	**Day**								

F: Acceptance Inspection, Quality Evaluation and Monitoring after Work

- The above should be implemented based on the equipment specification submitted by the provider.
- The above should be implemented according to the work procedure and implementation processes specified by the company.

G: Implementing Organization

1. Organizational Structure



2. Responsibility for Implementation

- The Manager shall be responsible for creating and administering the plan, determining how to execute the plan, and instructing staff on how to cope with contingency situations, such as accidents.
- The Deputy Manager in charge of signal equipment shall be responsible for developing the maintenance plan, instructing staff on how to manage the signal equipment, materials and tools and initiating emergency responses in the case of accidents, as well as assigning staff at the site as appropriate.
- The Deputy Manager in charge of communication equipment shall be responsible for developing the maintenance plan, instructing staff on how to manage the communication equipment, materials and tools and initiating emergency responses in the case of accidents, as well as assigning staff at the site as appropriate.
- The Section Engineer shall be responsible for developing the plan for the specialized area in his charge, creating work rules and guidelines, developing the equipment maintenance and management plan, and developing emergency response measures in case of an accident.
- The Leader shall be responsible for instructing and providing guidance to workers during maintenance work, reporting the result of maintenance work directly to the supervisor, and directly initiating emergency responses in the case of accidents.
- The communication inspection and repair worker shall be responsible for maintaining the communication equipment according to the rules and procedures specified by the law or company, and directly initiating emergency responses in the case of accidents.

- The signal inspection and repair worker shall be responsible for maintaining the signal equipment according to the rules and procedures specified by the law or company, and directly initiating emergency responses in the case of accidents.

3. Revision and Additions

The Manager of the Signal and Communication Equipment Inspection and Repair Center has the right to make proposals and/or propositions with regard to revisions and additions to this manual in order to appropriately perform signal communication equipment maintenance of the Line 2A.

Such proposals and/or propositions presented to HQ shall be made in accordance with the regulation.

JICA-Supported Project of Reinforcement of Urban Railway Regulatory Agency and Establishment of Operating Company in the City of Hanoi

Materials:

Draft of Equipment maintenance manual
〈Line 2A signal equipment〉

Implementer: **Nguyen Viet Quan**
JICA TA Team: Mr Takeshi Ikeda

November 30, 2015 in Hanoi

Contents

2. Monthly Maintenance Plan (Form)

3. Long-term Maintenance Plan (Form)

4. Budget Planning (Form)

F: Acceptance Inspection, Quality Evaluation and Monitoring after Work

G: Implementing Organization

1. Organizational Structure

2. Responsibility for Implementation

3. Revision and Additions

Attached Reference Materials

1. **Organizational Structure, Functions and Assignment of Equipment Section at Headquarters (HQ) and in Field (OU)**
2. **Procedure for Calculating Necessary Number of OU Staff**
3. **Procedure for Calculating Costs of Required Maintenance Items (Including the guideline for creating the list of items that are to be managed in-house and the list of items to be outsourced)**
4. **Procedure for Creating Operational Plan relevant to Maintenance Work (Including the forms of the business plan and the update plan to be developed)**
5. **Guideline for Creating Staff Training and Education Plan**
6. **Criteria for Number of Units Installed**
7. **Provisions on Information Sharing**
8. **Guideline and Form for Creating Equipment Ledger**
9. **Ledger Form of Equipment Durable Years**

A: Legal Foundation

1. Laws and Regulations

- Vietnam Railway Act 2005:
- Contents of this regulation shall be compliant with the laws and regulations of Vietnam. Currently, regulations and standards concerning operation and maintenance of the urban railway are being prepared in Vietnam. After the above regulations and standards are officially announced, we must update and recreate our regulations in order to comply with them.

2. Relevant Materials

- Circular No. 20/2013/TT-BGTVT dated 2013/8/16 on Management and Maintenance of Railway Structure.
- Circular No. 05/2015/TT-BGTVT dated 2015/3/30 on Standard for Operating Staff of Urban Railway.
- Circular No. 52/2014/TT-BCA on Management, Storage and Maintenance of Fire Extinguishing Means.
- Circular No. 07/2014/TT-BLĐTBXH on Announcement of Technological Safety Verification Process 27 of Machines and Equipment that are under the jurisdiction the Ministry of Labor, Disabled Veterans and Society, and are required to satisfy stringent safety requirements.
- Circular No.21/2015/TT-BGTVT on Working Hours and Break Time of Employees Who Engage in Specific Operations in Railway Transportation.
- Standard QCVN No. 06:2011/BGTVT on Railway Signals.
- Standard QCVN No. 08:2015/BGTVT on Railway Operation.

Standard QCVN No. 09:2010/BTTTT on Earth Connection at Communication Site.

- TCVN No. 8585:2011 on Urban Railway for Fast and Mass Transit

Basic Standard TCCS No.01:2009/VNRA on Design, Construction and Acceptance Inspection of Railway Signal Communication Construction

- General Railway Structure Maintenance Standard TCCS No. 02:2014/VNRA
- Seamless Railway Structure Maintenance Standard TCCS No. 03:2014/VNRA

Standard TCCS No.05:2014/VNRA on Goods, Materials and Accessory Products used for Railway Maintenance Work.

- Railway Communication Facility Maintenance Standard TCCS No.08:2014/VNRA
- Railway Signal Facility Maintenance Standard TCCS No.09:2014/VNRA

Standard TCCS No.10:2014/VNRA on Goods, Materials, Equipment and Parts used for Railway Signal Communication Maintenance Work.

- Specifications provided by equipment provider/contractor
- Technology design for the Line 2A (Cat Linh-Ha Dong) Equipment (Chinese consultant)
- Technology Design for Line 3 (Nhon-Ha Noi Station) Equipment (A French consultant)
- Technology Design for Line 2 (Nam Thang Long-Tran Hung Dao) Equipment (A Japanese consultant)
- Other Reference Material from TA Project
- Training Plan Ver 16.0 for the Line 2A (Cat Linh-Ha Dong)

3. Purpose

The Signal Equipment Maintenance Manual has been established in order to maintain the technical standard related to the equipment and also to help ensure stable operation of the signal equipment by making sure that the maintenance staff's work practices and procedures are consistent with the regulations.

4. Definition of Terms and Interpretation of Abbreviations

4.1. Definition of Terms

The term equipment denotes the communication equipment, signal equipment, electric power equipment and station equipment.

Communication equipment is the provision used to ensure safe operation and provide communication for passenger service.

Signal equipment consists of the interlocking device and the signal system that controls trains for the safe operation.

Electric power equipment is the provision that supplies power from a distribution board to each station's equipment and power to trains for travel from an electric power substation.

The electric room of a station is the room containing equipment that supplies power to station equipment.

The electric room of a depot is the room containing equipment that supplies power to depot equipment..

Station equipment refers to the equipment in a station that utilizes electricity excluding AFC equipment, communication equipment and signal equipment.

Equipment maintenance refers to work processes necessary to ensure and maintain normal operations of equipment as specified in the course of business transactions. Equipment maintenance work includes inspections, maintenance, repairs and quality verification of equipment.

Inspection means identifying the condition of equipment either by using intuition or by use of specialized tools in order to identify a failure or potential failure, and requesting recovery-related actions when a failure is detected.

Periodic inspections involve inspecting each item of equipment based on the cycle specified for them in order to maintain them in normal condition up to the next inspection.

Extraordinary inspection refers to an inspection other than the periodic inspection that takes place as needed in the wake of an accident, equipment modification or disaster.

Maintenance denotes the activities of monitoring, maintaining and repairing equipment on a continual or regular basis in order to ensure normal operation of each item of equipment and to reduce potential failures.

Repair is the activity of fixing failures that have occurred in the course of equipment operation to ensure safe railway operations. Repair comprises both periodic and extraordinary repair work.

Periodic repair refers to replacement of a section or part, or adjustment that is carried out on a regular basis according to the specified troubleshooting or maintenance procedure of each item of equipment.

Extraordinary repairs are carried out when a safe rail transportation is affected by an accident, transportation-related problem, disaster, etc.

Design quality validation inspects and validates the quality, and evaluates compliance of the given item of equipment with the relevant design requirements.

Maintenance staff denotes the Manager, Deputy Manager, Section Engineers, Leaders and workers at the Center.

The maintenance plan is a table that summarizes necessary maintenance work processes being planned in chronological order. The maintenance plan comprises the inspection plan, maintenance plan, repair plan and budget plan.

Patrol is the work of identifying environmental changes as well as the condition of equipment installed in a particular location that requires maintenance to help ensure equipment is managed appropriately and accidents are prevented.

The Equipment Inspection Standard Table contains the inspection items indispensable in the periodic inspection.

The Inspection Base Date refers to the day designated for the periodic inspection.

The Inspection Base Date Control Table is used to control the inspection base date for every item of equipment.

The Periodic Inspection Roadmap is a table that summarizes the longest inspection cycle set for each item of equipment in the equipment inspection standard table.

Monthly Workload Planning shows the maintenance work of a month in a table form.

Annual Workload Planning shows the maintenance work of a year in a table form.

Long-term Workload Planning shows the multi-year maintenance work in a table form.

Inspection Table is used to record results of the equipment inspection.

Work Instructions provide instructions necessary during equipment maintenance.

The operating Report is used to report the result of the completed equipment maintenance.

Equipment Maintenance Manual describes the procedures, precautions, manual work procedures, operation method, etc. necessary to carry out the equipment maintenance.

4.2 Abbreviations

HQ: Headquarters

OU (Operation Unit): Local companies

BGTVT: Ministry of Traffic and Transportation

BCA: Ministry of Public Safety

BCT: Ministry of Industry and Commerce

BLĐTBXH: Ministry of Industrial Injury and Society

ĐSĐT: Urban railway

QCVN: National Technical Criteria

TCVN: National Technical Standard

TCCS: Base Criteria

QTKĐ: Verification process

ATC: Automatic Train Control

ATO: Automatic Train Operation

ATS: Automatic Train Supervision

ATP: Automatic Train Protection

PAS: Public Address Systems

AWS: Automatic Warning System

....

5. List of Signal Equipment

B: Requirements for Maintenance Facilities, Equipment and Staff

1. Requirements for Facilities and Equipment

1.1. Requirements for Facilities

Create a list of the maintenance facilities, devices and tools used to implement the maintenance process based on the specification, tools and devices of the signal equipment. The above list becomes the basis of future maintenance work.

List of Facilities, Tools and Devices used for Maintenance of Signal Equipment

Order	**Device name**	**Standard or specification**	**Intended purpose**	**Note**
1				
2				

1.2. Requirements for Signal Equipment

Decide on the equipment specifications for future repair and maintenance based on the specifications of equipment providers.

Signal Equipment Specification Table

Order	System names	Accessory equipment	Specification	Note
1	Orbital unit	*As per equipment provider*	*As per equipment provider*	
2	Signal	*As per equipment provider*	*As per equipment provider*	
3	Switch	*As per equipment provider*	*As per equipment provider*	
4	Interlocking device	*As per equipment provider*	*As per equipment provider*	
5	ATC device	*As per equipment provider*	*As per equipment provider*	
6	ATO device	*As per equipment provider*	*As per equipment provider*	
7	CTC (Centralized Traffic Control) device	*As per equipment provider*	*As per equipment provider*	
8	Other devices	*As per equipment provider*	*As per equipment provider*	
9	…			

- Spare equipment shall be stored in a separate location. Their quantity and quality shall be warranted for use as needed.

1.3. Requirements for Maintenance Tools and Devices

- Maintenance tools, devices and facilities must be kept in good condition at all times.
- Special equipment for emergency purposes must be kept in a separate location, and clear indicative information and appropriate guidance must be attached.

2. Requirements for Staff

2.1. Requirements for Number of Maintenance Staff

(How to calculate the number of necessary staff at HQ and OU based on the Line 2A education plan and the reference materials used in the TA project.)

2.1.1. How to calculate the number of No.2A staff

a. Number of managerial staff

- The number depends on the workload and administrative abilities.
+ Managerial staff may directly carry out maintenance work.
+ In order to ensure quality of the maintenance work, managerial staff other than the Manager should carry out the work in three shifts.
+ Manager and Deputy Manager must support Section Engineers in implementing the maintenance work.
- Should be determined based on the workload.
- The number should be determined based on the maintenance plan developed.

➔When Line 2A began operations, six managerial staff were assigned for management and implementation of maintenance work. On each of the staff was assigned as the Manager (also serves as the person in charge of communication), the Deputy Manager and Section Engineer.

b. Number of workers

- The number depends on the equipment maintenance workload.
- The number of each group represents the average number computed on the assumption that each has necessary capabilities to carry out the work.
- Holidays and sick leave taken by maintenance staff must be taken into consideration.

They are responsible for maintenance of the signal equipment (ATP, ATC, ATO, ATS, interlocking devices, etc.). For that purpose, 20 maintenance workers are assigned to the Line 2A (1.5 people/km according to the standard of Beijing Railway). The Line 2A is about 13 km long. Two groups are set up. Ten workers are allocated to each group. One of them is the Leader and nine are workers. One group maintains the signal equipment over a distance of 6.5 km. They carry out maintenance on a 3-shift system according to the shift roster set by the Manager of OU.

2.1.2. For reference when calculating the number of other staff

- The HQ and OU staff number calculation method and shift roster developed by the specialist in the TA project and C/P (See the attached material).

2.2. Requirements for Capacity and Skill Level of each Duty Position at Inspection and Repair Center

2.2.1. The Center Manager assumes total responsibility for all operations performed at the Center, and is responsible for providing guidance to Center employees to ensure they implement the allotted assignments. The Manager is responsible for all operations including those related to safety, service, emergency inspections and repairs, as well as cultural establishment. Therefore, the Manager of the Signal and Communication Equipment Inspection and Repair Center must meet the following requirements.

- Has a college education or above, and expert knowledge in signal and communication equipment management.
- Has more than three years experience in signal and communication equipment management.
- Is knowledgeable in the applicable laws and regulations, and complies with the rules of the organization.
- Has the ability to improve oneself via study, a good imagination, and the ability to be diplomatic when negotiating, and sufficient decision-making abilities.
- Has a certificate of health proving that they satisfy the health standard set by the Ministry of Medical Services.

2.2.2. The Deputy Manager in charge of communication at OU shall assist the Manager in executing the Center's operations and assume the responsibility for managing the communication equipment. Therefore, the Deputy Manager of the Signal and Communication Equipment Inspection and Repair Center must meet the following requirements.

- Has a college education or above, and expert knowledge in communication equipment management.
- Has more than two years experience in signal and communication equipment management.
- Is knowledgeable in the applicable laws and regulations, and complies with the rules of the organization.
- Has the ability to improve oneself via study, a good imagination, and the ability to be diplomatic when negotiating.

2.2.3. The Deputy Manager in charge of signal at OU shall assist the Manager in executing the Center's operations and assume the responsibility for managing the signal equipment. Therefore, the Deputy Manager of the Signal and Communication Equipment Inspection and Repair Center must meet the following requirements.

- Has a college education or above, and expert knowledge in signal equipment management.
- Has more than two years of experience in the signal equipment management.
- Is knowledgeable in the applicable laws and regulations, and complies with the rules of the organization.
- Has the ability to improve oneself via study, a good imagination, and the ability to be diplomatic when negotiating.

2.2.4. The Signal Section Engineer must manage technology related to the signal equipment, manage failures and implement recovery measures in urgent situations. Therefore, the Signal Section Engineer must meet the following requirements.

- Has a college education or above
- Has expert knowledge about principles of the signal equipment system, understands the technical processes, technical standard and recovery measures in the case of urgent accidents, and a high degree of skill in handing software for office use as well as sophisticated special software such as CAD.

- Has the ability to improve oneself via study, a good imagination, and the ability to be diplomatic when negotiating.

2.2.5. The Communication Section Engineer must manage technology related to the communication equipment, manage failures and implement recovery measures in urgent situations. Therefore, the Communication Section Engineer must meet the following requirements.

- Has a college education or above
- Has an expert knowledge about the principle of the communication equipment system, understands the technical processes, technical standard and recovery measures in the case of urgent accidents, and a high degree of skill in handing software for office use as well as sophisticated special software such as CAD.
- Has the ability to improve oneself via study, a good imagination, and the ability to be diplomatic when negotiating.

2.2.6. The signal equipment maintenance worker is responsible for maintaining the signal equipment according to the rules and procedures specified by the company, and rescuing others urgently and directly should an accident or failure occur. Therefore, the signal equipment maintenance worker must meet the following requirements.

- Has a high school education or above
- Has special knowledge, a qualification or a maintenance-related certificate for the signal equipment.
- Has the ability to improve oneself via study, a good imagination, and complies with organization rules.

2.2.7. Communication equipment maintenance workers are responsible for maintaining the communication equipment according to the rules and procedures specified by the company, and rescuing others urgently and directly should an accident or failure occur. Therefore, the communication equipment maintenance worker must meet the following requirements.

- Has a high school education or above
- Has special knowledge, a qualification or a maintenance-related certificate for the communication equipment.
- Has the ability to improve oneself via study, a good imagination, and complies with organization rules.

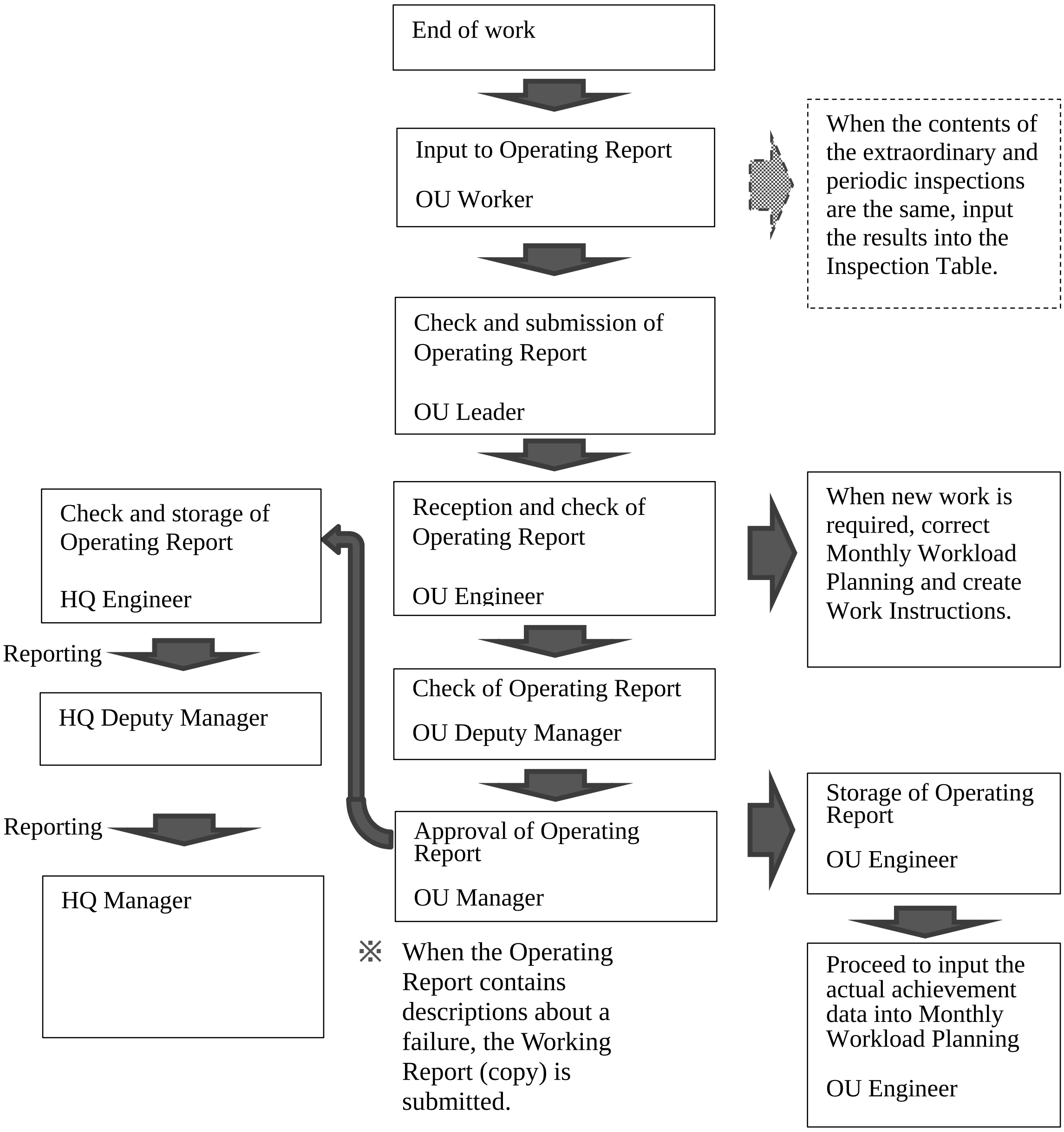
C: Classification of Maintenance Operations and Work Implementation Flow

1. Classification of Maintenance Operations

- Equipment maintenance work must include the inspection, maintenance, repairs and quality verification of the equipment.
- The equipment inspection must include a periodic inspection and an extraordinary inspection. The equipment inspection must include an overall inspection and a detailed inspection.
- Equipment repair work must include periodic repairs and extraordinary repairs.

2. Work Implementation Flow

2.1. Operating Report Preparation Flow



2.2. Flow of Entry of Actual Achievement to Monthly Workload Planning

Storage of Operating Report

OU Engineer

Proceed to input the actual achievement data into Monthly Workload Planning

OU Engineer

Proceed to check of actual achievement in Monthly Workload Planning

OU Deputy Manager

After work results in the Monthly Workload Planning have been validated, the Monthly Workload Planning (copy) is submitted.

Approval of actual achievement in Monthly Workload Planning

OU Manager

Check of actual achievement in Monthly Workload Planning and its storage

HQ Engineer

Storage of Monthly Workload Planning

OU Engineer

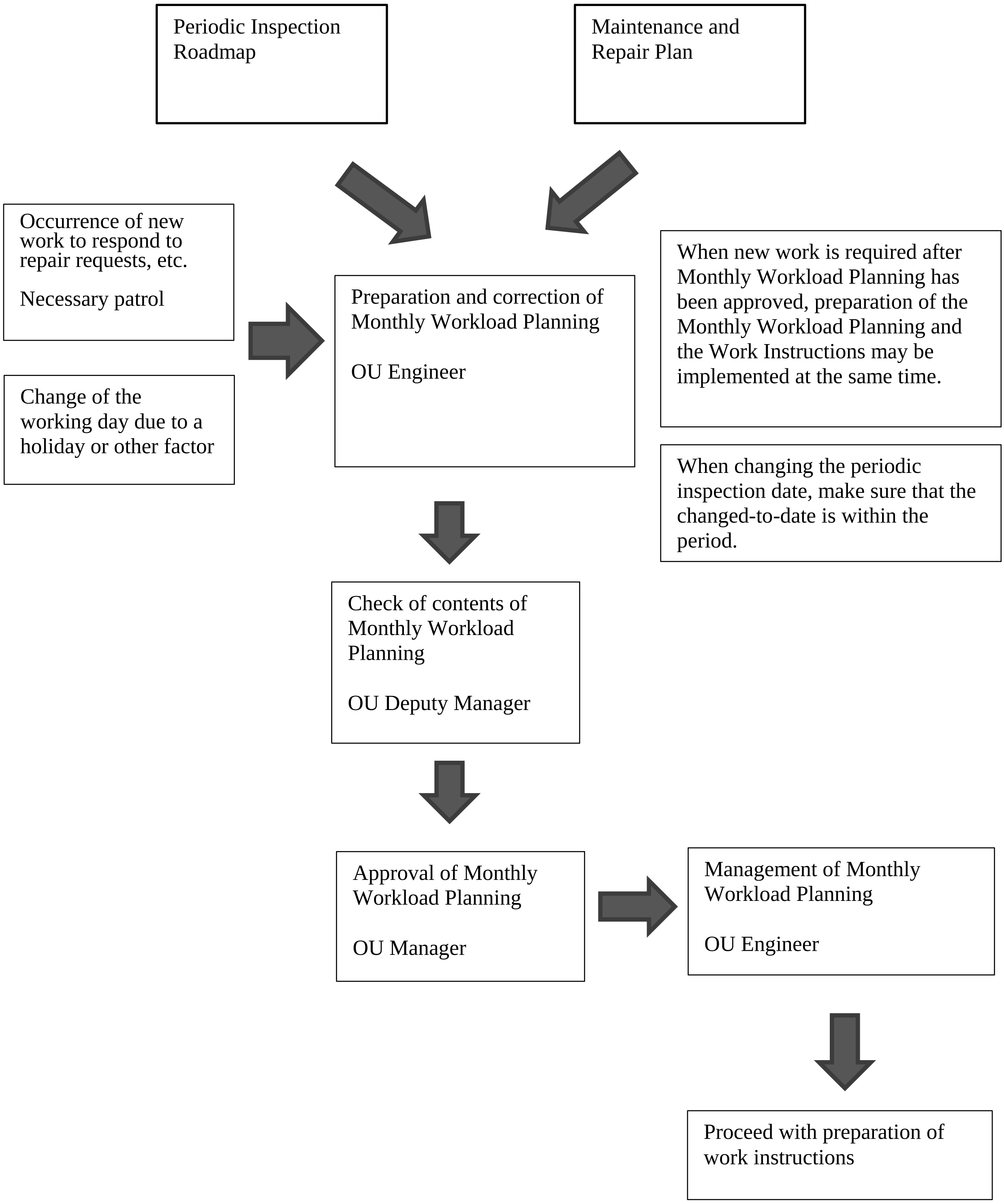
Reporting

HQ Deputy Manager

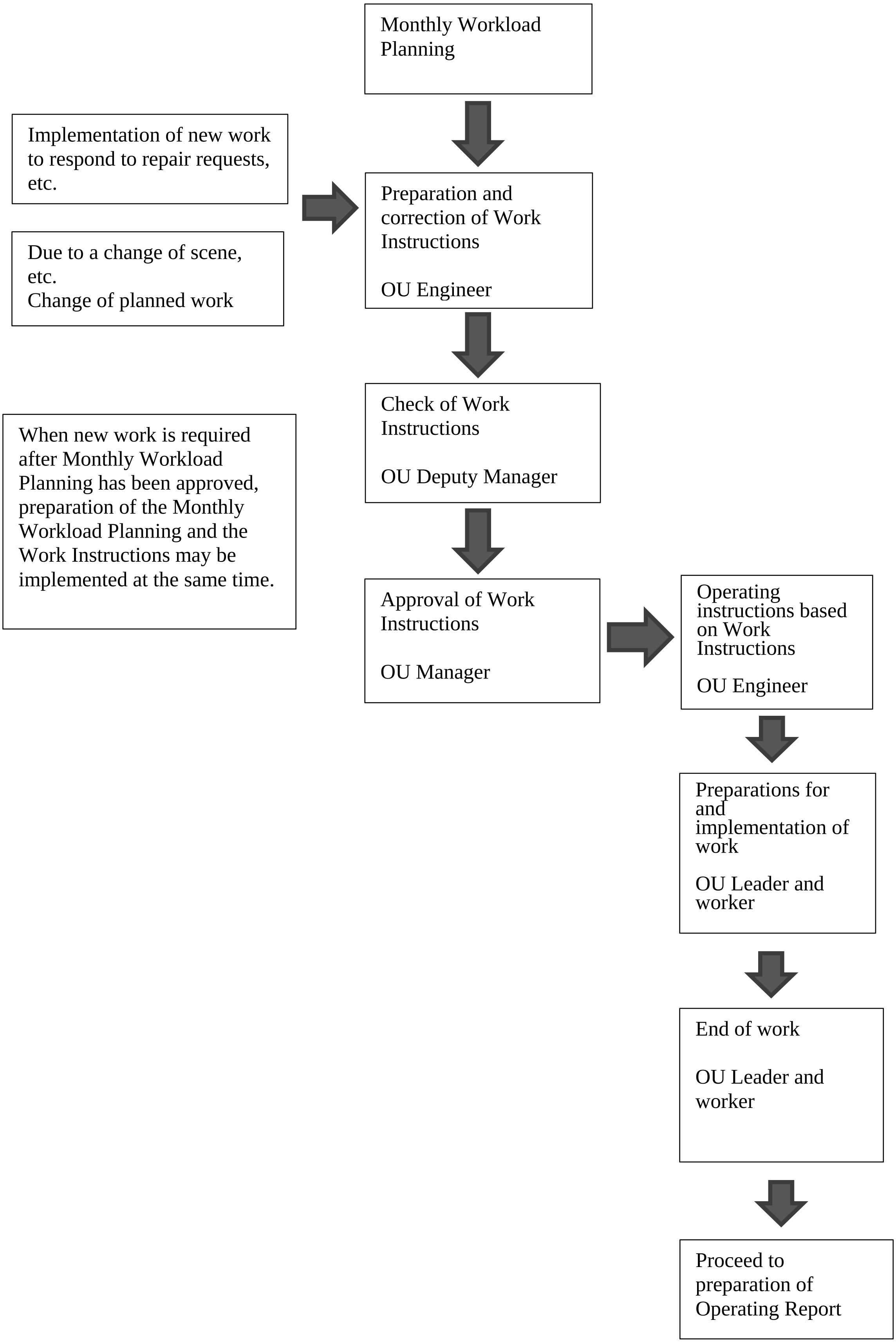
Reporting

HQ Manager

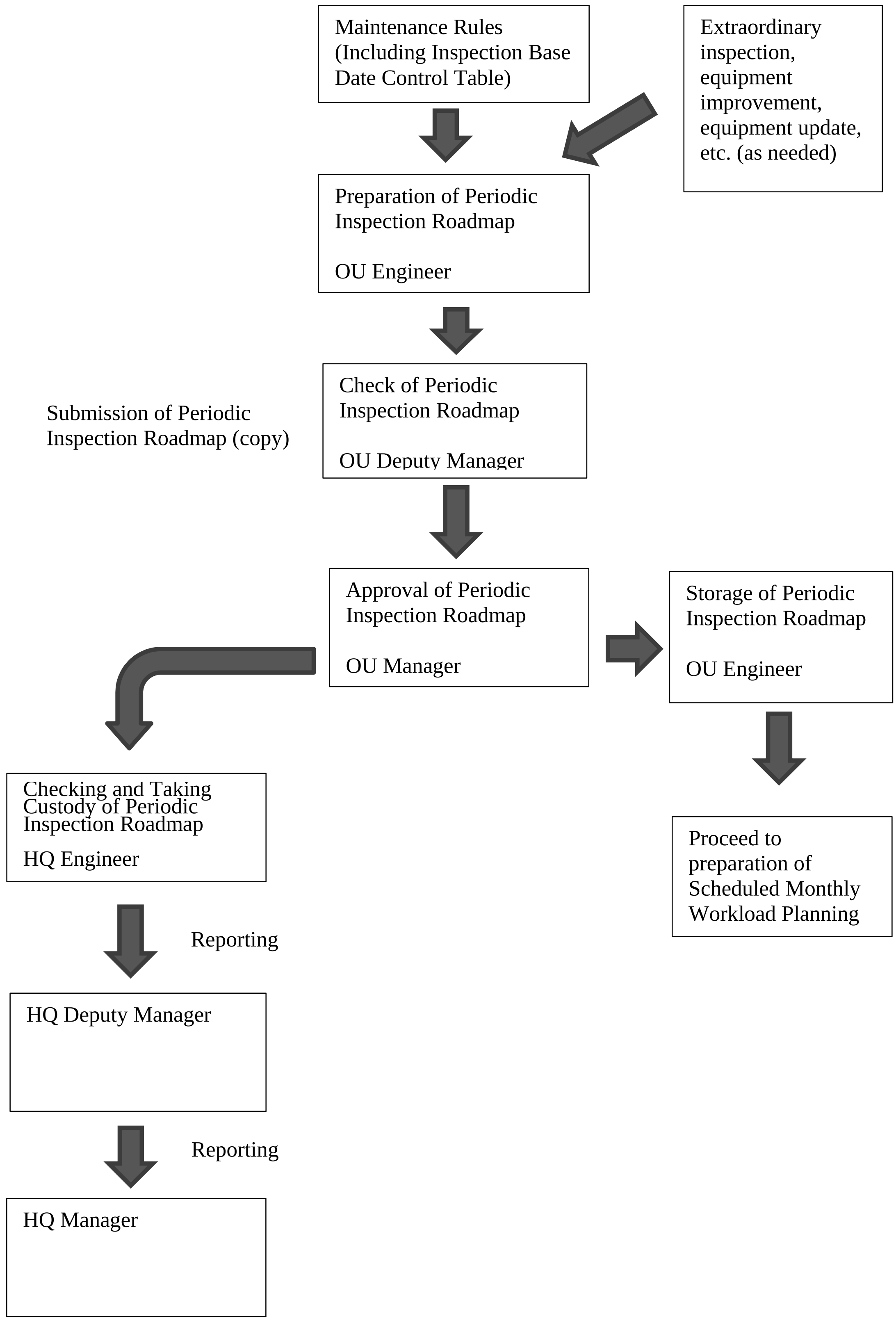
2.3. Monthly Workload Planning Preparation Flow



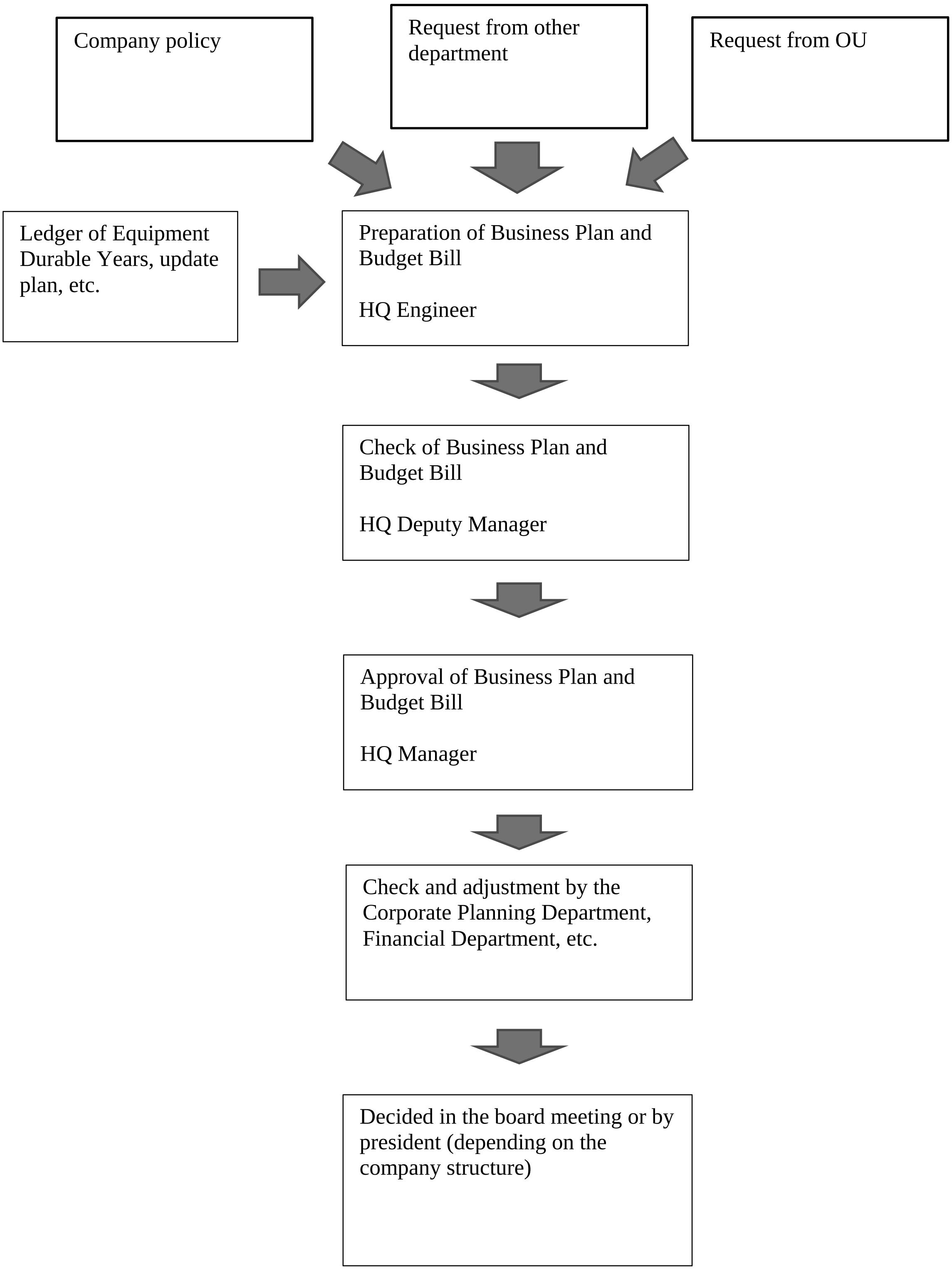
2.4. Work Instructions Preparation Flow



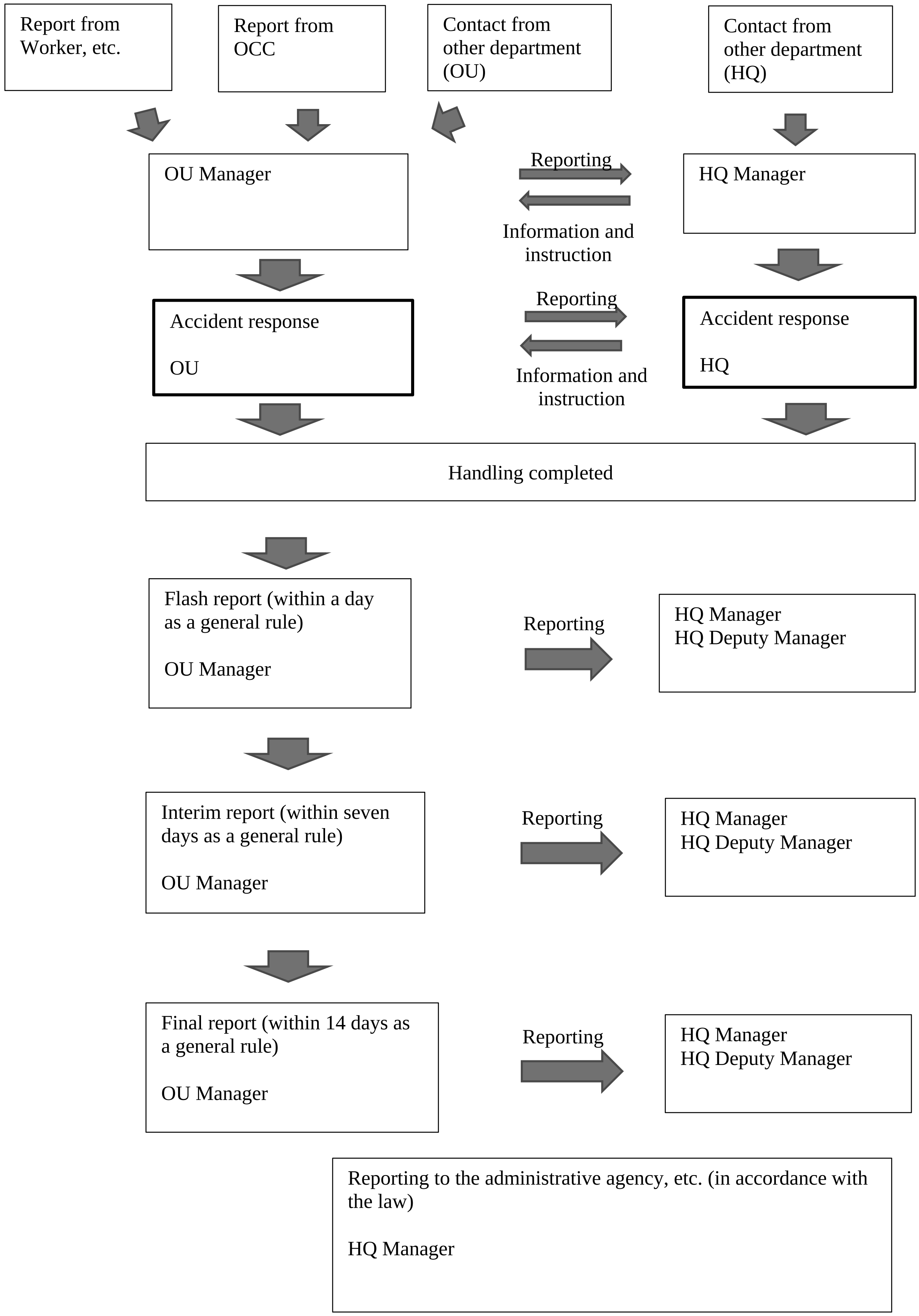
2.5. Periodic Inspection Roadmap (Long Term) Preparation Flow



2.6. Business Plan and Budget Preparation Flow



2.7. Flow of Response to Accidents and Transport Disorders



D: Survey Measurement and Validation of Equipment Condition

1. Installation Location

- Inspect appropriateness of the equipment referencing the working and design drawings.
- Be sure to inspect and measure the installation location based on the provisions and procedures described in the approved Work Instructions.

2. Validation of Equipment Operating Status

2.1. Overall Inspection of Equipment

- Acceptability of the operating status
- Acceptability of the installed condition
- Check whether a problem resulted from environment, weather, etc.
- Check presence or absence of stains, damages, etc.
- Check presence or absence of abnormal odors, noises, etc.

2.2. Detailed Equipment Inspection

Order	System names	Contents of inspection *(For reference only)*	Inspection cycle	Note
1	Orbital unit	1. Acceptability of insulation state of rails 2. Acceptability of impedance bond, terminals, wiring and mechanism 3. Track circuit (1) Suitability of voltage, etc. (2) Suitability in train detection 4. Signal bonds: Acceptability of terminals		
2	Signal including supporting materials	1. Acceptability of wiring and mechanism 2. Appropriateness of voltage		
3	Switch	Electric switch (1) Acceptability of lock (2) Acceptability of manual changeover (3) Acceptability of function and control (4) Suitability of voltage, etc. (5) Acceptability of wiring and mechanism (6) Acceptability of lubrication		
4	Interlocking device	1. Device body Acceptability of function and control 2. General function Acceptability of interface with relevant equipment		
5	ATC device	1. Device body (1) Acceptability of function and control (2) Appropriateness of ATC signal on-the-spot		

		2. General function Acceptability of interface with relevant equipment		
6	ATO device	ATO track antenna Acceptability of condition		
7	CTC (Centralized Traffic Control) device	1.OCC device (1) Acceptability of function and control (2) Acceptability of transmission (3) Acceptability of interface with relevant equipment 2. Station equipment (1) Acceptability of function and control (2) Acceptability of transmission (3) Acceptability of interface with relevant equipment 3. Transmission device (1) Acceptability of function and control (2) Acceptability of transmission (3) Acceptability of interface with relevant equipment		
8	Other devices (Signal)	1. Sign marker devices Acceptability of condition (Some sign markers use reflection board and LED other than paint) 2. PRC (Programmed Route Control) device (Small CTC device used at depots) (1) Acceptability of function and control (2) Acceptability of transmission (3) Acceptability of interface with relevant equipment 3. Supporting materials (Supporting column, supporting structure, piping, etc.) (1) Acceptability of condition (2) Acceptability of measures against damage caused by rats and disasters.		
9	. . .			

E: Development of Plan (*Create the form according to the Plan Preparation Manual)*

1. Plan of the Day (List the maintenance items of the day according to the Monthly Maintenance Plan)

1.1. Work Instructions

<table>
<tr><td rowspan="2">Work Instructions</td><td rowspan="2">Date and time
(Work implementation time specified in the Work Instructions)

Signal and Communication Equipment Inspection and Repair Center: the Line 2A</td><td>OU Manager
(Approver)</td><td>OU Deputy Manager
(Checker)</td><td>OU Engineer
(Preparer)</td></tr>
<tr><td>*(Signature)*</td><td>*(Signature)*</td><td>*(Signature)*</td></tr>
<tr><td>Time when a failure detected
(Describe date and time in detail)</td><td>Year __ Month __ Day __ Hour __</td><td>Requested by

(Signature)</td><td colspan="2">Including the reason why the failure was detected
Station, alarm, periodic inspection, patrol and other</td></tr>
<tr><td>Location and equipment name</td><td></td><td>Work code
(When provided)</td><td colspan="2"></td></tr>
<tr><td>Work name</td><td colspan="4"></td></tr>
<tr><td colspan="5">Contents of instruction (What, how, by when, current situation, drawings, etc.)</td></tr>
<tr><td colspan="5"></td></tr>
<tr><td colspan="5">Precautions for work (A special location, requirements, precautions for work)</td></tr>
<tr><td colspan="5">1</td></tr>
<tr><td colspan="5">2</td></tr>
</table>

1.2. Operating Report

Working hours	Day/ Night	Materials used (To be clearly indicated in the instructions)	Available/ Unavailable	Arrangement Date	Receipt of material

Operating Report	Date repair completed	Date	Reported by (Signature of Leader)

	OU Manager	OU Deputy Manager	OU Engineer
Confirmation of completion			

Correction of records in Inspection Table	Input to Monthly Failure Report	Correction of maintenance drawing	Correction of Equipment Ledger	Input to Shipping/Receiving Card
Yes/No/Finished	Yes/No/Finished	Yes/No/Finished	Yes/No/Finished	Yes/No/Finished

Date	Name of worker	Contents of work (Survey, Treatment, Result, Materials used, and Hand-off)	Check by OU Deputy Manager (When work of the shift is not completed)

Cause, treatment, comments	Model of removed item	Model of installed item
	Serial number of removed item	Serial number of installed item
	Date of manufacturing of removed item	Date of manufacturing of installed item
	Name of manufacturer of removed item	Name of manufacturer of installed item

Necessity for request of special repair (When approval of HQ Station Equipment Section is necessary)	Necessary / Not necessary

2. Monthly Maintenance Plan (Form)

<table>
<tr><td colspan="3" rowspan="2">Revision history</td><td colspan="3" rowspan="2">Year _ Month _ Workload Planning
Department: Signal and Communication Equipment Inspection and Repair Center</td><td colspan="3">Hanoi Metro Company
The Line 2A</td></tr>
<tr><td>Plan

(Signature)</td><td>Actual achievement

(Signature)</td><td>Note</td></tr>
<tr><td rowspan="2">Day</td><td rowspan="2">Month</td><td colspan="3">Contents of inspection</td><td>Location of inspection</td><td></td><td></td><td rowspan="15"><On Addition of and Change in Work>
(1) When there was an addition or change in the scheduled work, describe it in the table using a pencil.
(2) When an addition work is completed, indicate it using a red pencil.
Connect the work before and after it with an arrow.
(3) Select the applicable reason for the change from the following and write its number near the arrow.
"List of reasons of addition or</td></tr>
<tr><td>Shift 1</td><td>Shift 2</td><td>Shift 3</td><td></td><td></td><td></td></tr>
<tr><td>1</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
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<tr><td>12</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>13</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table>

14								change" 1. Because of a change in the working schedule due to a holiday or other factors. 2. Because of the influence of an addition or change in other work. 3. Because of an accident or disaster. 4. Because of the convenience of the business partner. 5. Because of addition of all-night feed 6. Because of equipment failure. 7. Because of an extraordinary inspection due to equipment failure or other factor. 8. Because the work was added after the scheduled job was completed. 9. Other reason (Describe it clearly and in an easy-to-understand manner) <On actual achievement of work> (1) When the scheduled work was
15								
....								
30								
31								

								implemented, affix a "Completed" seal next to the end of the name of the work. (2) When work that was added or changed is completed, affix a "Completed" seal to the portion furnished with rubrics after the change.

3. Long-term Maintenance Plan (Form)

Sheet number/Total number of sheets	**Periodic Maintenance Plan** **Department: Signal and Communication Equipment Inspection and Repair Center**					Hanoi Metro Company Route: 2A												
Maintenance type	Equipment name	Contents of inspection	Inspection code	Inspection period	Location of inspection	(Year)												(Year)
						January	February	March	April	May	June	July	August	September	October	November	December	
Inspection																		
......																		
Maintenance																		
....																		
Repair																		
......																		

- Long-term Maintenance Plan may be created for the periods of one year, five years, 10 years and 30 years.

4. Budget Planning (Form)

<table>
<tr><td colspan="10" align="center">Maintenance Budget Planning - Year __
Department: Signal Equipment Section</td></tr>
<tr><td colspan="3">Sheet number/Total number of sheets</td><td colspan="7">Route: the Line 2A</td></tr>
<tr><td colspan="2">Maintenance time</td><td rowspan="2">Contents of work</td><td rowspan="2">Method of implementation</td><td rowspan="2">Equipment use period</td><td rowspan="2">Maintenance cycle</td><td rowspan="2">Durable years</td><td rowspan="2">Total implementation cost</td><td rowspan="2">Cost breakdown</td><td rowspan="2">Note</td></tr>
<tr><td>Month</td><td>Day</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
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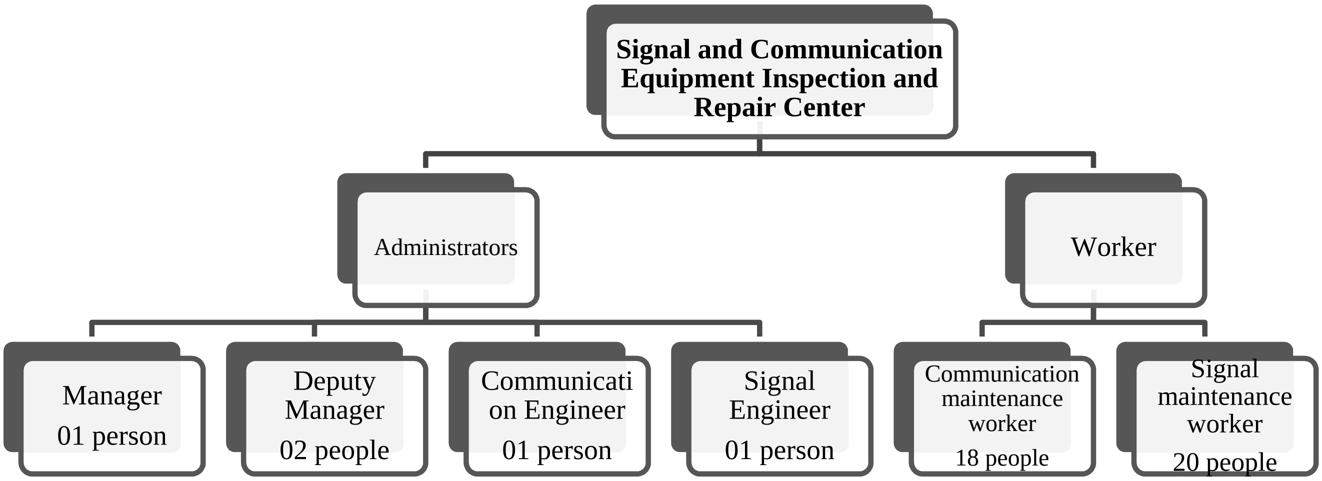
</table>

F: Acceptance Inspection, Quality Evaluation and Monitoring after Work

- The above should be implemented based on the equipment specification submitted by the provider.
- The above should be implemented according to the work procedure and implementation processes specified by the company.

G: Implementing Organization

1. Organizational Structure



2. Responsibility for Implementation

- The Manager shall be responsible for creating and administering the plan, determining how to execute the plan, and instructing staff on how to cope with contingency situations, such as accidents.
- The Deputy Manager in charge of signal equipment shall be responsible for developing the maintenance plan, instructing staff on how to manage the signal equipment, materials and tools and initiating emergency responses in the case of accidents, as well as assigning staff at the site as appropriate.
- The Deputy Manager in charge of communication equipment shall be responsible for developing the maintenance plan, instructing staff on how to manage the communication equipment, materials and tools and initiating emergency responses in the case of accidents, as well as assigning staff at the site as appropriate.
- The Section Engineer shall be responsible for developing the plan for the specialized area in his charge, creating work rules and guidelines, developing the equipment maintenance and management plan, and developing emergency response measures in case of an accident.
- The Leader shall be responsible for instructing and providing guidance to workers during maintenance work, reporting the result of maintenance work directly to the supervisor, and directly initiating emergency responses in the case of accidents.
- The communication inspection and repair worker shall be responsible for maintaining the communication equipment according to the rules and procedures specified by the law or company, and directly initiating emergency responses in the case of accidents.

- The signal inspection and repair worker shall be responsible for maintaining the signal equipment according to the rules and procedures specified by the law or company, and directly initiating emergency responses in the case of accidents.

3. Revision and Additions

The Manager of the Signal and Communication Equipment Inspection and Repair Center has the right to make proposals and/or propositions with regard to revisions and additions to this manual in order to appropriately perform signal communication equipment maintenance of the Line 2A.

Such proposals and/or propositions presented to HQ shall be made in accordance with the regulation.

JICA-Supported Project of Reinforcement of Urban Railway Regulatory Agency and Establishment of Operating Company in the City of Hanoi

Materials:

Draft of Equipment maintenance manual 〈Line 2A electric power equipment〉

Implementer: **Nguyen Viet Quan**

JICA TA Team: Mr Takeshi Ikeda

November 30, 2015 in Hanoi

Contents

3. Long-term Maintenance Plan (Form)

4. Budget Planning (Form)

F: Acceptance Inspection, Quality Evaluation and Monitoring after Work

G: Implementing Organization

1. Organizational Structure

2. Responsibility for Implementation

3. Revision and Additions

Attached Reference Materials

1. **Organizational Structure, Functions and Assignment of Maintenance Section at Headquarters (HQ) and in Field (OU)**
2. **Procedure for Calculating Necessary Number of OU Staff**
3. **Procedure for Calculating Costs of Required Maintenance Items (Including the guideline for creating the list of items that are to be managed in-house and the list of items to be outsourced)**
4. **Procedure for Creating Operational Plan relevant to Maintenance Work (Including the forms of the business plan and the update plan to be developed)**
5. **Guideline for Creating Staff Training and Education Plan**
6. **Criteria for Number of Units Installed**
7. **Provisions on Information Sharing**
8. **Guideline and Form for Creating Equipment Ledger**
9. **Ledger Form of Equipment Durable Years**

A: Legal Foundation

1. Laws and Regulations

- Vietnam Railway Act 2005:
- Contents of this regulation shall be compliant with the laws and regulations of Vietnam. Currently, regulations and standards concerning operation and maintenance of the urban railway are being prepared in Vietnam. After the above regulations and standards are officially announced, we must update and recreate our regulations in order to comply with them.

2. Relevant Materials

- Vietnam Railway Act 2005:
- Circular No. 20/2013/TT-BGTVT dated 2013/8/16 on Management and Maintenance of Railway Structure.
- Circular No. 05/2015/TT-BGTVT dated 2015/3/30 on Standard for Operating Staff of Urban Railway.
- Circular No. 07/2014/TT-BLĐTBXH on Announcement of Technological Safety Verification Process 27 of Machines and Equipment that are under the jurisdiction the Ministry of Labor, Disabled Veterans and Society, and are required to satisfy stringent safety requirements.
- Circular No.21/2015/TT-BGTVT on Working Hours and Break Time of Employees Who Engage in Specific Operations in Railway Transportation.
- Standard QCVN No. 06:2011/BGTVT on Railway Signals.
- Standard QCVN No. 08:2015/BGTVT on Railway Operation.

Standard QCVN No. 09:2010/BTTTT on Earth Connection at Communication Site.

- Standard QCVN No. QĐT-5: 2009 on Verification of Electrical System Facility.
- National Technical Standard QCVN No. 01:2008/ BCT on Electric Safety.
- TCVN No. 8585:2011 on Urban Railway for Fast and Mass Transit

Basic Standard TCCS No.01:2009/VNRA on Design, Construction and Acceptance Inspection of Railway Signal Communication Construction

- General Railway Structure Maintenance Standard TCCS No. 02:2014/VNRA
- Seamless Railway Structure Maintenance Standard TCCS No. 03:2014/VNRA
- Specifications provided by equipment provider/contractor
- Technology design for the Line 2A (Cat Linh-Ha Dong) Equipment (Chinese consultant)
- Technology Design for Line 3 (Nhon-Ha Noi Station) Equipment (A French consultant)
- Technology Design for Line 2 (Nam Thang Long-Tran Hung Dao) Equipment (A Japanese consultant)
- Other Reference Material from TA Project
- Training Plan Ver 16.0 for the Line 2A (Cat Linh-Ha Dong)

3. Purpose

The electric power equipment Maintenance Manual has been established in order to maintain the technical standard related to the equipment and also to help ensure stable operation of the electric power equipment by making sure that the maintenance staff's work practices and procedures are consistent with the regulations.

4. Definition of Terms and Interpretation of Abbreviations

4.1. Definition of Terms

The term equipment denotes the communication equipment, signal equipment, electric power equipment and station equipment.

Communication equipment is the provision used to ensure safe operation and provide communication for passenger service.

Signal equipment consists of the interlocking device and the signal system that controls trains for the safe operation.

Electric power equipment is the provision that supplies power from a distribution board to each station's equipment and power to trains for travel from an electric power substation.

The electric room of a station is the room containing equipment that supplies power to station equipment.

The electric room of a depot is the room containing equipment that supplies power to depot equipment..

Station equipment refers to the equipment in a station that utilizes electricity excluding AFC equipment, communication equipment and signal equipment.

Equipment maintenance refers to work processes necessary to ensure and maintain normal operations of equipment as specified in the course of business transactions. Equipment maintenance work includes inspections, maintenance, repairs and quality verification of equipment.

Inspection means identifying the condition of equipment either by using intuition or by use of specialized tools in order to identify a failure or potential failure, and requesting recovery-related actions when a failure is detected.

Periodic inspections involve inspecting each item of equipment based on the cycle specified for them in order to maintain them in normal condition up to the next inspection.

Extraordinary inspection refers to an inspection other than the periodic inspection that takes place as needed in the wake of an accident, equipment modification or disaster.

Maintenance denotes the activities of monitoring, maintaining and repairing equipment on a continual or regular basis in order to ensure normal operation of each item of equipment and to reduce potential failures.

Repair is the activity of fixing failures that have occurred in the course of equipment operation to ensure safe railway operations. Repair comprises both periodic and extraordinary repair work.

Periodic repair refers to replacement of a section or part, or adjustment that is carried out on a regular basis according to the specified troubleshooting or maintenance procedure of each item of equipment.

Extraordinary repairs are carried out when a safe rail transportation is affected by an accident, transportation-related problem, disaster, etc.

Design quality validation inspects and validates the quality, and evaluates compliance of the given item of equipment with the relevant design requirements.

Maintenance staff denotes the Manager, Deputy Manager, Section Engineers, Leaders and workers at the Center.

The maintenance plan is a table that summarizes necessary maintenance work processes being planned in chronological order. The maintenance plan comprises the inspection plan, maintenance plan, repair plan and budget plan.

Patrol is the work of identifying environmental changes as well as the condition of equipment installed in a particular location that requires maintenance to help ensure equipment is managed appropriately and accidents are prevented.

The Equipment Inspection Standard Table contains the inspection items indispensable in the periodic inspection.

The Inspection Base Date refers to the day designated for the periodic inspection.

The Inspection Base Date Control Table is used to control the inspection base date for every item of equipment.

The Periodic Inspection Roadmap is a table that summarizes the longest inspection cycle set for each item of equipment in the equipment inspection standard table.

Monthly Workload Planning shows the maintenance work of a month in a table form.

Annual Workload Planning shows the maintenance work of a year in a table form.

Long-term Workload Planning shows the multi-year maintenance work in a table form.

Inspection Table is used to record results of the equipment inspection.

Work Instructions provide instructions necessary during equipment maintenance.

The operating Report is used to report the result of the completed equipment maintenance.

Equipment Maintenance Manual describes the procedures, precautions, manual work procedures, operation method, etc. necessary to carry out the equipment maintenance.

4.2 Abbreviations

HQ: Headquarters

OU (Operation Unit): Local companies

BGTVT: Ministry of Traffic and Transportation

BCA: Ministry of Public Safety

BCT: Ministry of Industry and Commerce

BLĐTBXH: Ministry of Industrial Injury and Society

ĐSĐT: Urban railway

QCVN: National Technical Criteria

TCVN: National Technical Standard

TCCS: Base Criteria

QTKĐ: Verification process

ATC: Automatic Train Control

ATO: Automatic Train Operation

ATS: Automatic Train Supervision

ATP: Automatic Train Protection

PAS: Public Address Systems

AWS: Automatic Warning System

....

5. List of Power Facilities

B: Requirements for Maintenance Facilities, Equipment and Staff

1. Requirements for Facilities and Equipment

1.1. Requirements for Facilities

Create a list of facilities, devices and tools used to implement the maintenance process based on the based on the specifications of the electric power equipment and the requirements for tools and devices. The above list becomes the basis of future maintenance work.

List of Facilities, Tools and Devices used for Maintenance of Electric power equipment

Order	**Device name**	**Standard or specification**	**Intended purpose**	**Note**
1				
2				

1.2. Requirements for Equipment

Decide on the equipment specifications for future repair and maintenance based on the specifications of equipment providers.

Electric power equipment Specification Table

Order	System names	Accessory equipment	Specification	Note
1	Cable	*As per equipment provider*	*As per equipment provider*	
2	Transformer (low voltage)	*As per equipment provider*	*As per equipment provider*	
3	Main potential transformer for rectifier	*As per equipment provider*	*As per equipment provider*	
4	Distribution board	*As per equipment provider*	*As per equipment provider*	
5	Enclosed AC switchboard	*As per equipment provider*	*As per equipment provider*	
6	Enclosed DC switchboard	*As per equipment provider*	*As per equipment provider*	
7	DC breaker	*As per equipment provider*	*As per equipment provider*	
8	Section over protective equipment	*As per equipment provider*	*As per equipment provider*	
9	Emergency block system	*As per equipment provider*	*As per equipment provider*	
10	Earthing device	*As per equipment provider*	*As per equipment provider*	
11	Third rail	*As per equipment*	*As per equipment*	

		provider	*provider*	
12	Land marks and sign markers	*As per equipment provider*	*As per equipment provider*	
13	....			

- Spare equipment shall be stored in a separate location. Their quantity and quality shall be warranted for use as needed.

1.3. Requirements for Maintenance Tools and Devices

- Maintenance tools, devices and facilities must be kept in good condition at all times.
- Special equipment for emergency purposes must be kept in a separate location, and clear indicative information and appropriate guidance must be attached.

2. Requirements for Staff

2.1. Requirements for Number of Maintenance Staff

(How to calculate the number of necessary staff at HQ and OU based on the Line 2A education plan and the reference materials used in the TA project.)

2.1.1. How to calculate the number of No.2A staff

a. Number of managerial staff

- The number depends on the workload and administrative abilities.

+ Managerial staff may directly carry out maintenance work.

+ In order to ensure quality of the maintenance work, managerial staff other than the Manager should carry out the work in three shifts.

+ Manager and Deputy Manager must support Section Engineers in implementing the maintenance work.

- Should be determined based on the workload.
- The number should be determined based on the maintenance plan developed.

➔ When Line 2A began operations, four managerial staff were assigned to the line. Namely, they were a Manager, a Deputy Manager and two Section Engineers.

b. Number of workers

- The number depends on the equipment maintenance workload.
- Holidays and sick leave taken by maintenance staff must be taken into consideration.
- Three workers shall be allocated to each of the main transformer stations according to the standard set down for the Line 2A. Six main transformer stations are installed for each station of the Line 2A.

➔Number of electric power inspection and repair workers

3 workers x 6 transformer stations = 18 workers

One Leader and 17 workers engage in maintenance of equipment in the transformer station. Workers of two shifts in a 3-shift system are on duty of maintenance. The shift roster approved by the Manager must be observed (The number of workers of a team varies depending on the workload and the number of equipment items subject to maintenance).

2.1.2. For reference when calculating the number of other staff

- The HQ and OU staff number calculation method and shift roster developed by the specialist in the TA project and C/P (See the attached material).

2.2. Requirements for Capacity and Skill Level of each Duty Position at Inspection and Repair Center

2.2.1. The Center Manager assumes the total responsibility for all operations performed at the Center, and provides guidance to the Center employees to ensure they implement the alloted assignments. The Manager is responsible for all operations including those related to safety, service, emergency inspections and repairs, as well as cultural establishment. Therefore, the Manager meet the following requirements.

- Has a college education or above, and expert knowledge on management of the electric power equipment.
- Has more than three years of experience in the electric power equipment management.
- Is knowledgeable in the applicable laws and regulations, and complies with the rules of the organization.
- Has the ability to improve oneself via study, a good imagination, and the ability to be diplomatic when negotiating, and has sufficient decision-making abilities.
- Has a certificate of health proving that they satisfy the health standard set by the Ministry of Medical Services.

2.2.2. The Deputy Manager shall assist the Manager in executing the Center's operations, and share and manage the field of safety, production and general affairs of the Center. Therefore, the Deputy Manager must meet the following requirements.

- Has a college education or above, and expert knowledge on management of the electric power equipment.
- Has more than two years of experience in the electric power equipment management.
- Is knowledgeable in the applicable laws and regulations, and complies with the rules of the organization.
- Has the ability to improve oneself via study, a good imagination, and the ability to be diplomatic when negotiating.

2.2.3. The Electricity Section Engineer assumes the responsibility of managing the electric power equipment-related technology, handling failures and implementing recovery measures in urgent situations. Therefore, the Electricity Section Engineer must meet the following requirements.

- Has a college education or above
- Has an expert knowledge about the principle of the electric power equipment system, understands the technical processes, technical standard and recovery measures in urgent situations, and a high degree of skill in handing software for office use as well as sophisticated special software such as CAD.
- Has the ability to improve oneself via study, a good imagination, and the ability to be diplomatic when negotiating.

2.2.4. The electric power equipment maintenance worker is responsible for maintaining the electric power equipment according to the rules and procedures specified by the company, and rescuing others urgently and directly should an accident or failure occur. Therefore, the worker must meet the following requirements.

- Has a high school education or above
- Has special knowledge, a qualification or a maintenance-related certificate for the electric power equipment.
- Has the ability to improve oneself via study, a good imagination, and complies with organization rules.

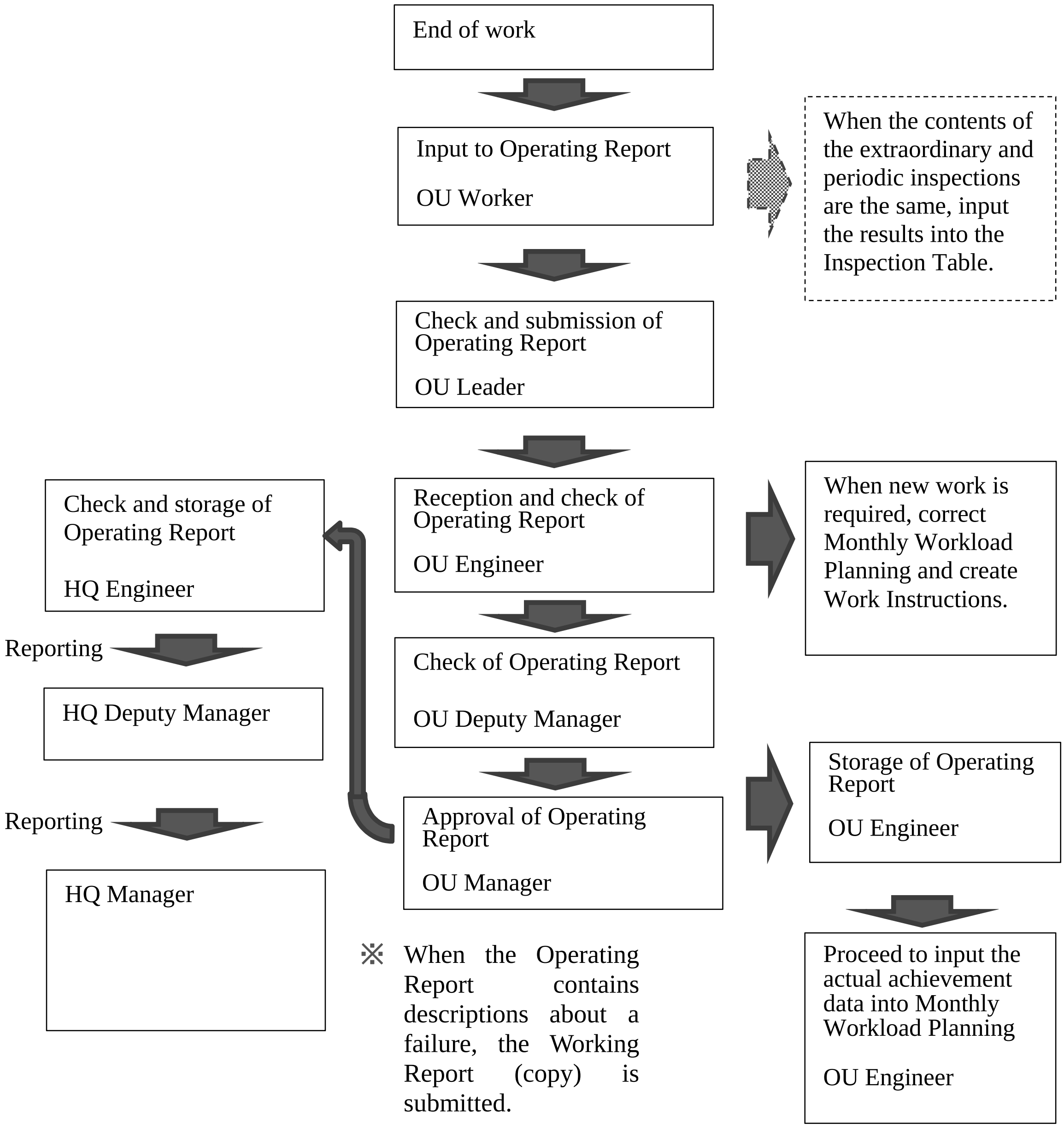
C: Classification of Maintenance Operations and Work Implementation Flow

1. Classification of Maintenance Operations

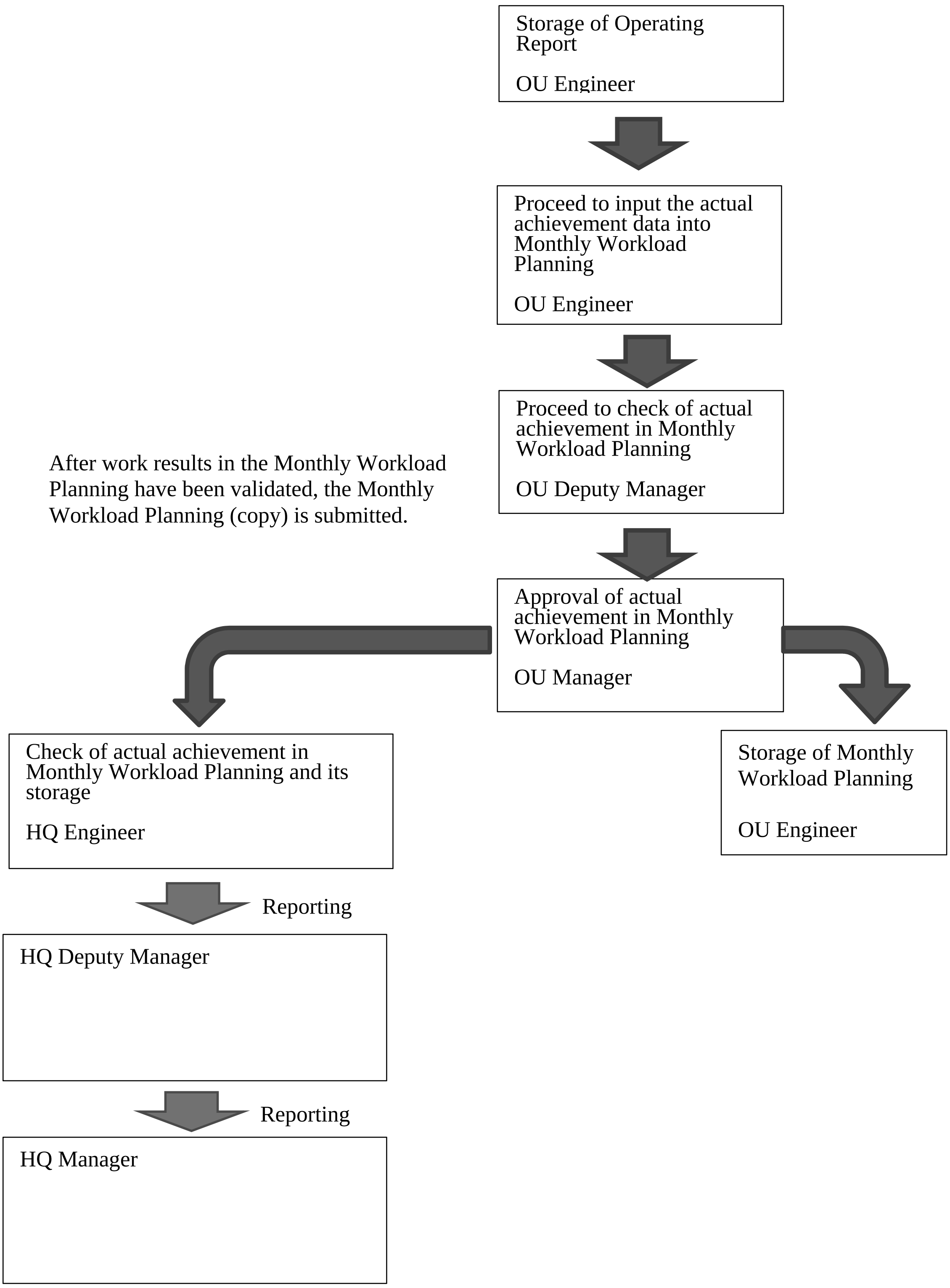
- Equipment maintenance work must include the inspection, maintenance, repairs and quality verification of the equipment.
- The equipment inspection must include a periodic inspection and an extraordinary inspection. The equipment inspection must include an overall inspection and a detailed inspection.
- Equipment repair work must include periodic repairs and extraordinary repairs.

2. Work Implementation Flow

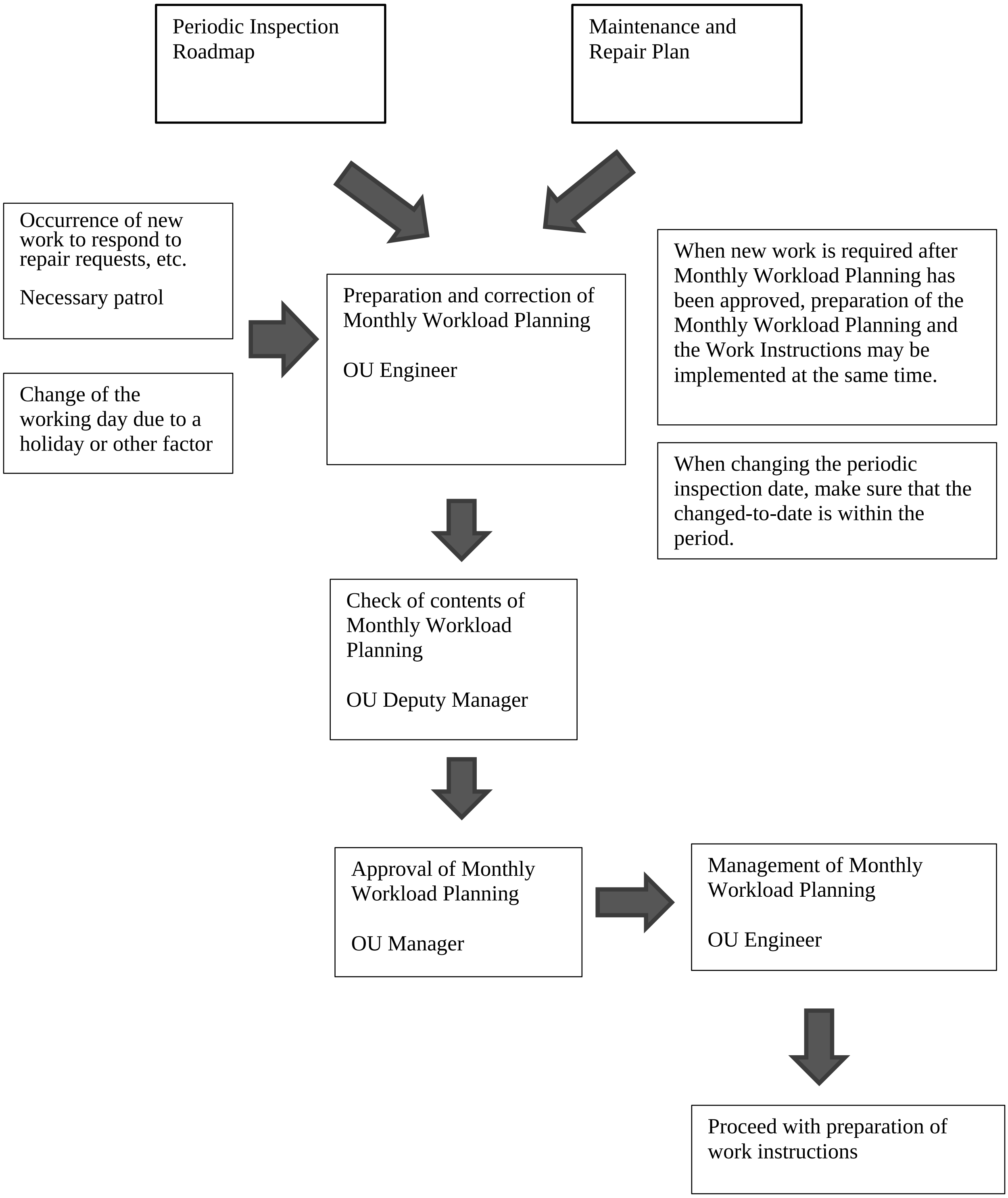
2.1. Operating Report Preparation Flow



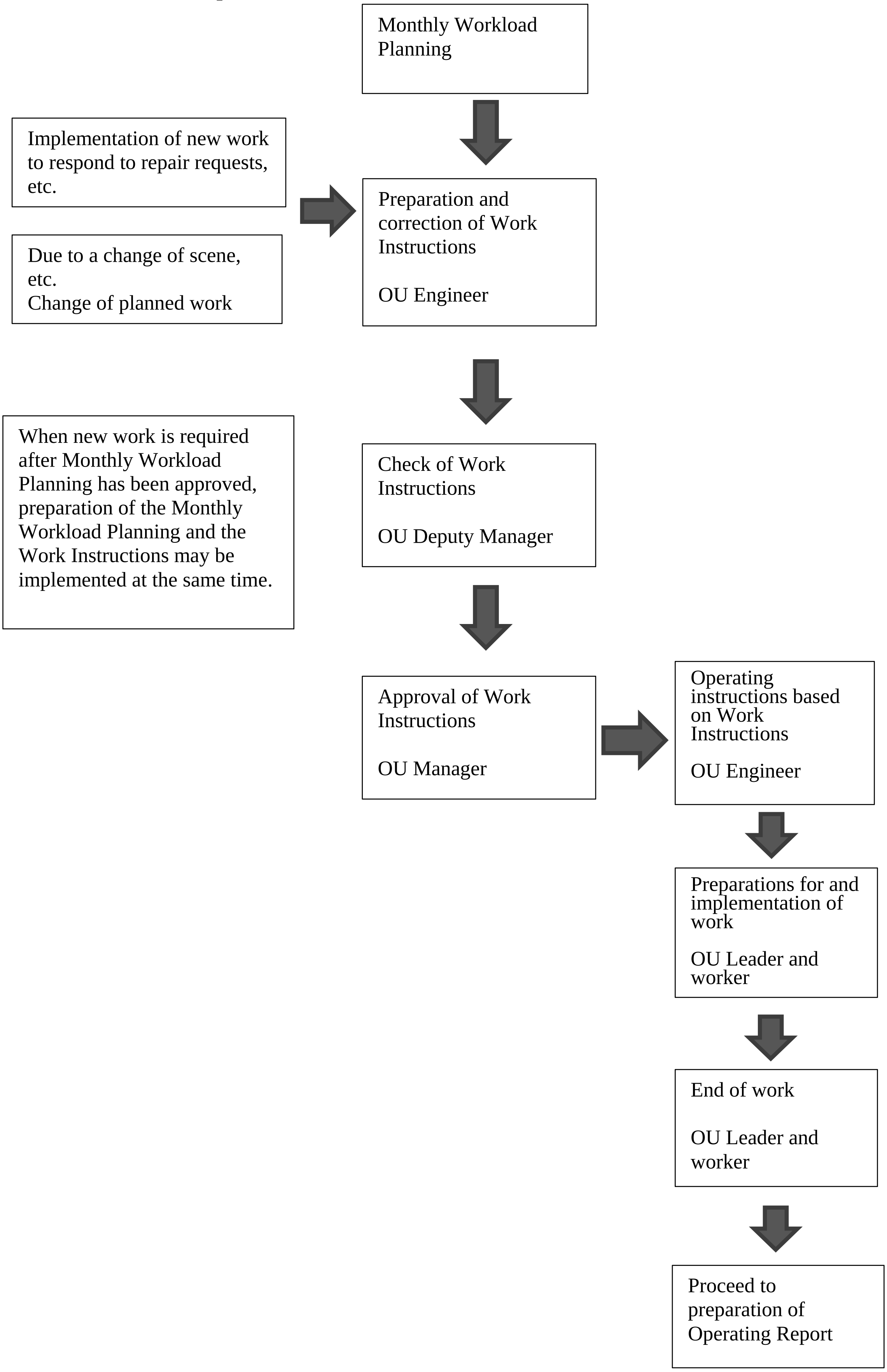
2.2. Flow of Entry of Actual Achievement to Monthly Workload Planning



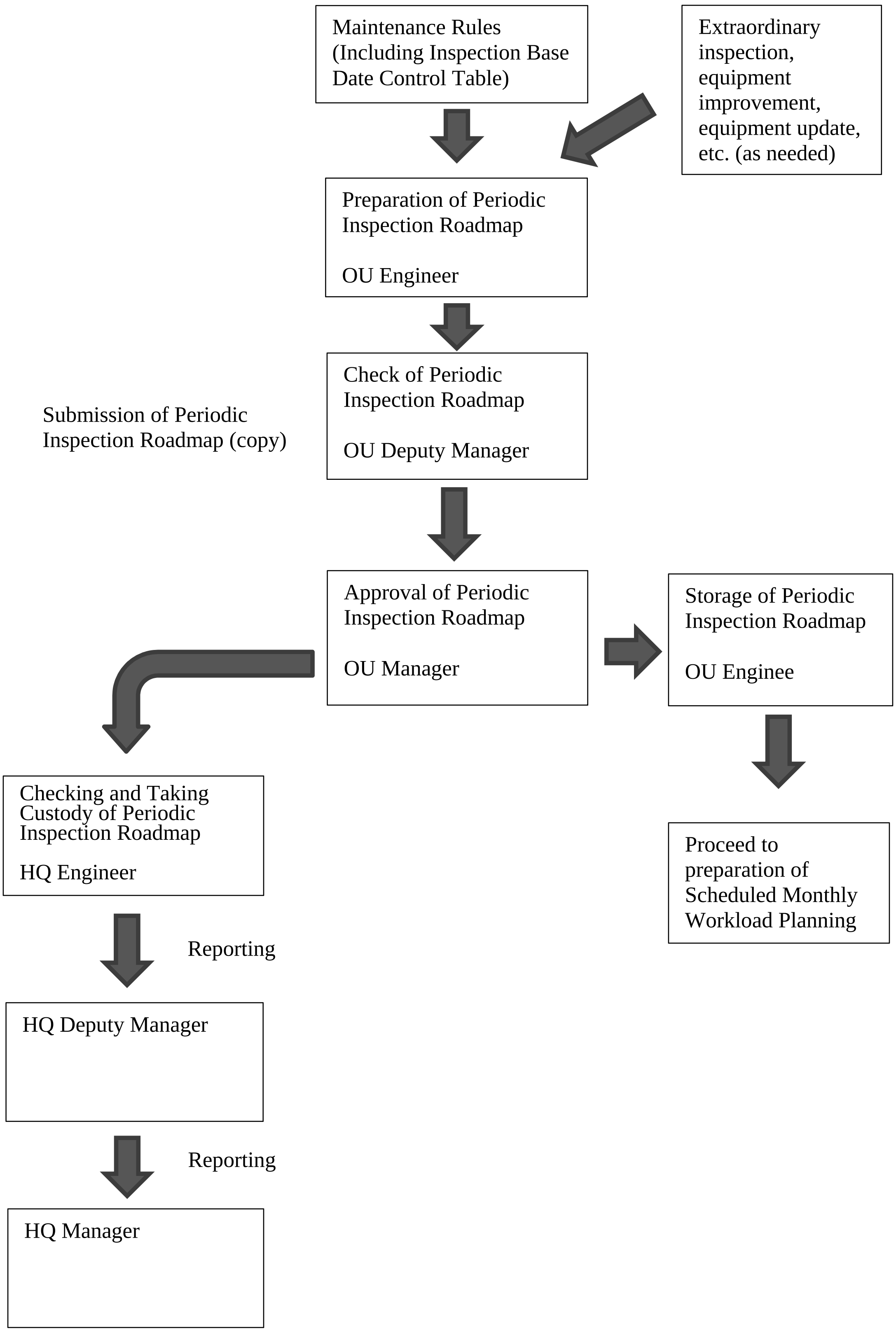
2.3. Monthly Workload Planning Preparation Flow



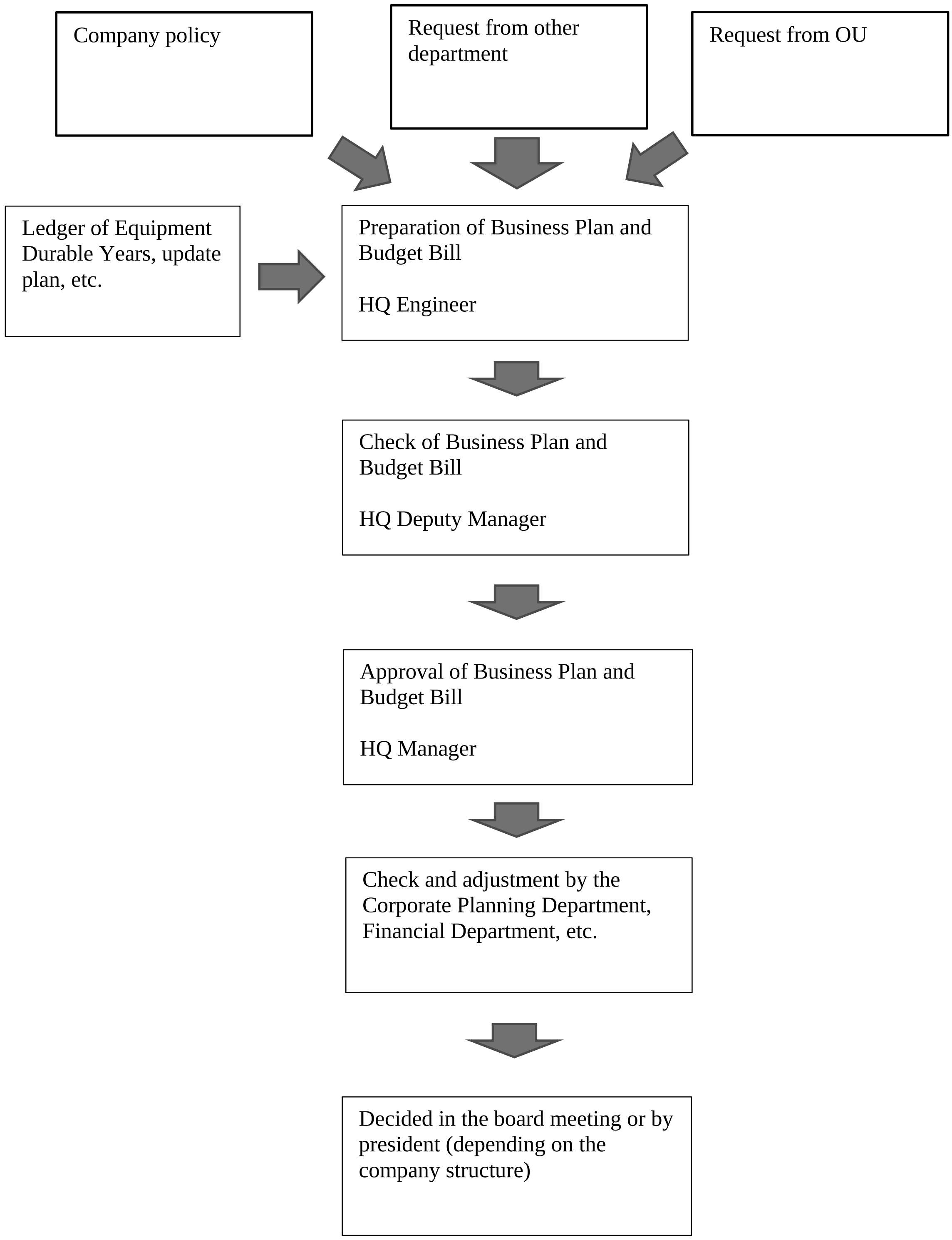
2.4. Work Instructions Preparation Flow



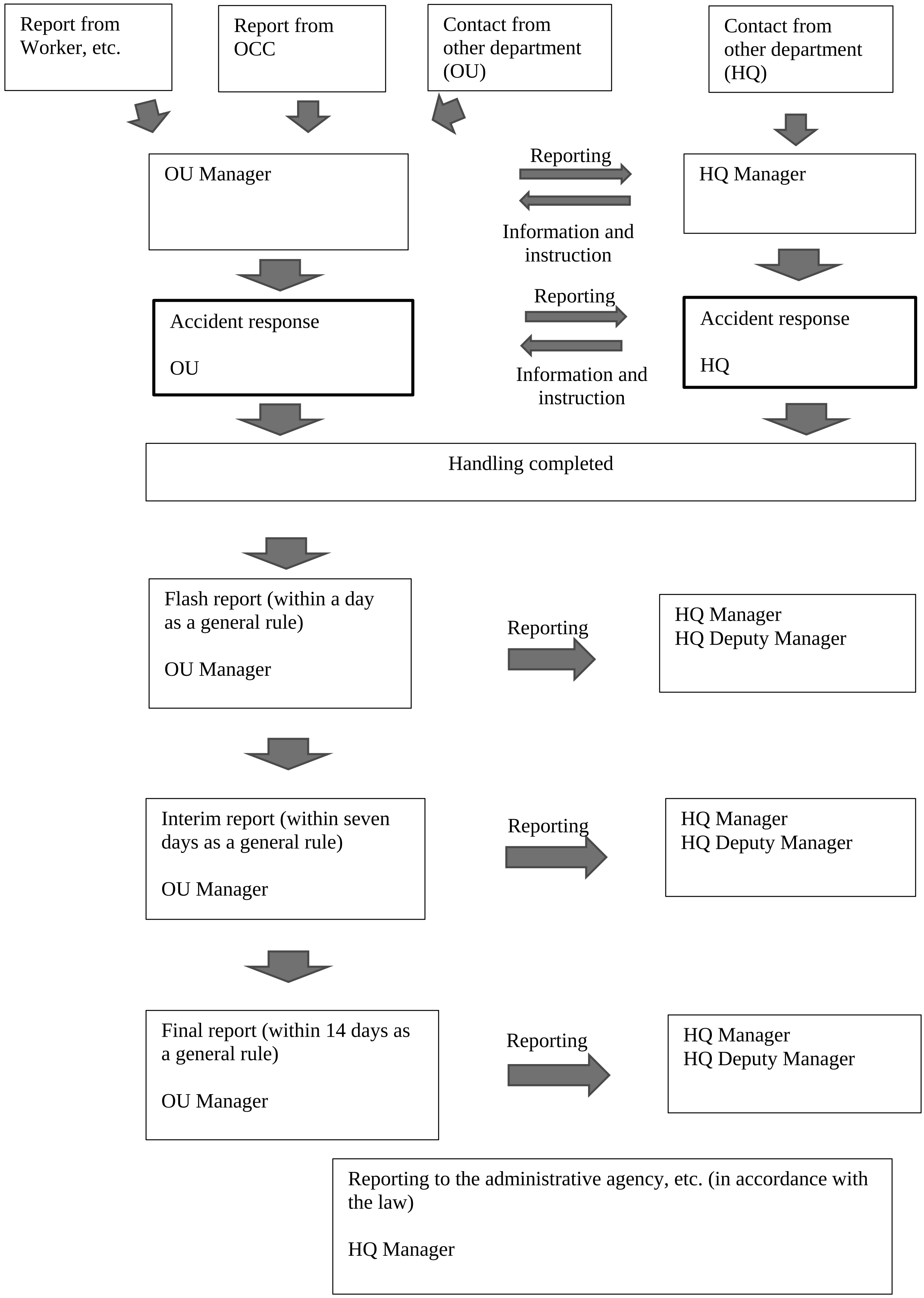
2.5. Periodic Inspection Roadmap (Long Term) Preparation Flow



2.6. Business Plan and Budget Preparation Flow



2.7. Flow of Response to Accidents and Transport Disorders



D: Survey Measurement and Validation of Equipment Condition

1. Installation Location

- Inspect appropriateness of the equipment referencing the working and design drawings.
- Be sure to inspect and measure the installation location based on the provisions and procedures described in the approved Work Instructions.

2. Validation of Equipment Operating Status

2.1. Overall Inspection of Equipment

- Acceptability of the operating status
- Acceptability of the installed condition
- Check whether a problem resulted from environment, weather, etc.
- Check presence or absence of stains, damages, etc.
- Check presence or absence of abnormal odors, noises, etc.

2.2. Detailed Equipment Inspection

Order	System names	Contents of inspection *(For reference only)*	Inspection cycle	Note
1	Circuit breaker	1. Acceptability of wiring and mechanism 2. Suitability of insulation resistance 3. Acceptability of operation and condition (including lubrication)		
2	Transformer	1. Acceptability of wiring and mechanism 2. Suitability of insulation resistance 3. Acceptability of operation and condition of accessory device		
3	Rectifier	1. Acceptability of wiring and mechanism 2. Suitability of insulation resistance 3. Acceptability of operation and condition of cooling system 4. Acceptability of operation and condition of accessory device		
4	Distribution board	1. Suitability of voltage, etc. 2. Acceptability of display 3. Acceptability of wiring and mechanism Acceptability of relay 4. Suitability of insulation resistance 5. Acceptability of sequence control (program-based control of conditions) Acceptability of control after the conditions are met		
5	Power management	1. Acceptability of function and control of OCC equipment		

	device	2. Acceptability of function and control of OU equipment 3. Acceptability of interface with relevant equipment (1) Acceptability of control (2) Acceptability of display		
6	Grounding wire	1. Acceptability of grounding wire 2. Suitability of earth resistance value		
7	Supporting materials (including supporting insulator)	1. Acceptability of various power poles, supporting brackets, accessory fixtures, insulation materials, etc. 2. Acceptability of trough, fire-proof compartment, etc. 3. Acceptability of measures against water leakage, water immersion, damage caused by rats and disasters. 4. Measurement of track clearance		
8	Positive feeder	1. Suitability of insulation resistance (= Leak current) 2. Acceptability cables, connections, etc. 3. Acceptability of installed condition 4. Acceptability of accessory device		
9	DC breaker	1. Acceptability of wiring and mechanism 2. Suitability of insulation resistance 3. Acceptability of operation and condition 4. Acceptability of accessory device		
10	Return circuit and grounding wire	1. Acceptability of negative feeder 2. Acceptability of return wire bond 3. Acceptability of accessory device 4. Acceptability of grounding electrode and grounding wire		
11	Third rail	1. Suitability of insulation resistance (= Leak current) 2. Acceptability of installed condition of third rail 3. Acceptability attached cables, connections, etc. 4. Acceptability of accessory device		
12	Land marks and sign markers	Acceptability of installed condition		
13	....			

E: Development of Plan (*Create the form according to the Plan Preparation Manual)* 1. Plan of the day (List the maintenance items of the day according to the Monthly Maintenance Plan)

1.1. Work Instructions

<table>
<tr><td rowspan="2">Work Instructions</td><td rowspan="2">Date and time
(Work implementation time specified in the Work Instructions)

Electric power equipment Inspection and Repair Center: the Line 2A</td><td>OU Manager
(Approver)</td><td>OU Deputy Manager
(Checker)</td><td>OU Engineer
(Preparer)</td></tr>
<tr><td>(Signature)</td><td>(Signature)</td><td>(Signature)</td></tr>
<tr><td>Time when a failure detected
(Describe date and time in detail)</td><td>Year __ Month __ Day __ Hour __</td><td>Requested by

(Signature)</td><td colspan="2">Including the reason why the failure was detected
Station, alarm, periodic inspection, patrol and other</td></tr>
<tr><td>Location and equipment name</td><td></td><td>Work code
(When provided)</td><td colspan="2"></td></tr>
<tr><td>Work name</td><td colspan="4"></td></tr>
<tr><td colspan="5">Contents of instruction (What, how, by when, current situation, drawings, etc.)</td></tr>
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<tr><td colspan="5"></td></tr>
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<tr><td colspan="5"></td></tr>
<tr><td colspan="5"></td></tr>
<tr><td colspan="5">Precautions for work (A special location, requirements, precautions for work)</td></tr>
<tr><td colspan="5">1</td></tr>
<tr><td colspan="5">2</td></tr>
</table>

1.2. Operating Report

Working hours	Day/ Night	Materials used (To be clearly indicated in the instructions)	Available/ Unavailable	Arrangement Date	Receipt of material

Operating Report	Date repair completed	Date	Reported by (Signature of Leader)

	OU Manager	OU Deputy Manager	OU Engineer
Confirmation of completion			

Correction of records in Inspection Table	Input to Monthly Failure Report	Correction of maintenance drawing	Correction of Equipment Ledger	Input to Shipping/Receiving Card
Yes/No/Finished	Yes/No/Finished	Yes/No/Finished	Yes/No/Finished	Yes/No/Finished

Date	Name of worker	Contents of work (Survey, Treatment, Result, Materials used, and Hand-off)	Check by OU Deputy Manager (When work of the shift is not completed)

Cause, treatment, comments	Model of removed item	Model of installed item
	Serial number of removed item	Serial number of installed item
	Date of manufacturing of removed item	Date of manufacturing of installed item
	Name of manufacturer of removed item	Name of manufacturer of installed item

Necessity for request of special repair (When approval of HQ Station Equipment Section is necessary)	Necessary / Not necessary

2. Monthly Maintenance Plan (Form)

<table>
<tr><td colspan="2" rowspan="2">Revision history</td><td colspan="4" rowspan="2">Year _ Month _ Workload Planning
Department: Electric power equipment Inspection and Repair Center</td><td colspan="3">Hanoi Metro Company
The Line 2A</td></tr>
<tr><td>Plan

(Signature)</td><td>Actual achievement

(Signature)</td><td>Note</td></tr>
<tr><td rowspan="2">Day</td><td rowspan="2">Month</td><td colspan="3">Contents of inspection</td><td>Location of inspection</td><td></td><td></td><td rowspan="18"><On Addition of and Change in Work>
(1) When there was an addition or change in the scheduled work, describe it in the table using a pencil.
(2) When an addition work is completed, indicate it using a red pencil.
Connect the work before and after it with an arrow.
(3) Select the applicable reason for the change from the following and write its number near the arrow.
"List of reasons of addition or change"
1. Because of a change in the working schedule due to a holiday</td></tr>
<tr><td>Shift 1</td><td>Shift 2</td><td>Shift 3</td><td></td><td></td><td></td></tr>
<tr><td>1</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
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<tr><td>14</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>15</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>....</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table>

30								or other factors.
31								2. Because of the influence of an addition or change in other work. 3. Because of an accident or disaster. 4. Because of the convenience of the business partner. 5. Because of addition of all-night feed 6. Because of equipment failure. 7. Because of an extraordinary inspection due to equipment failure or other factor. 8. Because the work was added after the scheduled job was completed. 9. Other reason (Describe it clearly and in an easy-to-understand manner) <On actual achievement of work> (1) When the scheduled work was implemented, affix a “Completed” seal next to the end of the name of the work. (2) When work that was added or changed is completed, affix a

								"Completed" seal to the portion furnished with rubrics after the change.

3. Long-term Maintenance Plan (Form)

Sheet number/Total number of sheets	Periodic Maintenance Plan Department: Electric power equipment Inspection and Repair Center					Hanoi Metro Company Route: 2A												
Maintenance type	Equipment name	Contents of inspection	Inspection code	Inspection period	Location of inspection	(Year)												(Year)
						January	February	March	April	May	June	July	August	September	October	November	December	
Inspection																		
......																		
Maintenance																		
....																		
Repair																		
......																		

- Long-term Maintenance Plan may be created for the periods of one year, five years, 10 years and 30 years.

4. Budget Planning (Form)

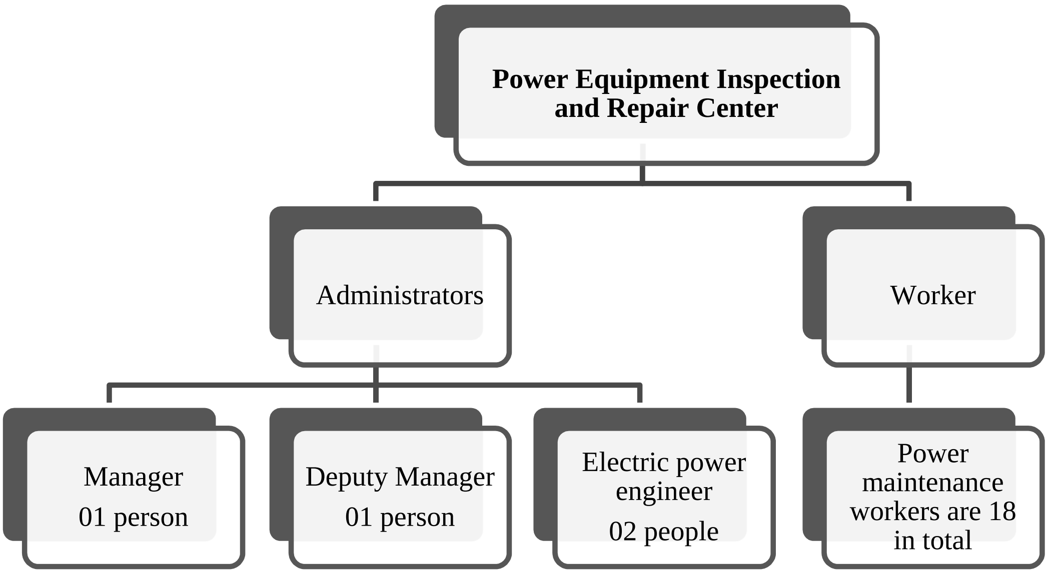
Maintenance Budget Planning - Year __ Department: electric power equipment Section Sheet number/Total number of sheets Route: the Line 2A										
Maintenance time		**Contents of work**	**Method of implementation**	**Equipment use period**	**Maintenance cycle**	**Durable years**	**Total implementation cost**	**Cost breakdown**	**Note**
Month	**Day**								

F: Acceptance Inspection, Quality Evaluation and Monitoring after Work

- The above should be implemented based on the equipment specification submitted by the provider.
- The above should be implemented according to the work procedure and implementation processes specified by the company.

G: Implementing Organization

1. Organizational Structure



2. Responsibility for Implementation

- The Manager shall be responsible for creating and administering the plan, determining how to execute the plan, and instructing staff on how to cope with contingency situations, such as accidents.
- The Deputy Manager shall be responsible for developing the safety-related plan, instructing staff on how to manage the electric power equipment, materials and tools and initiating emergency responses in the case of accidents, as well as assigning staff at the site as appropriate.
- The Power Section Engineer shall be responsible for developing the plan for his specialized area, creating work rules and guidelines, developing the equipment maintenance and management plan, and developing emergency response measures in case of an accident.
- The Leader shall be responsible for instructing and providing guidance to workers during maintenance work, reporting the result of maintenance work directly to the supervisor, and directly initiating emergency responses in the case of accidents.
- The power inspection and repair worker shall be responsible maintaining the electric power equipment according to the rules and procedures specified by the law or company, and directly initiating emergency responses in the case of accidents.

3. Revision and Additions

The Manager of the electric power equipment Inspection and Repair Center has the right to make proposals and/or propositions with regard to revisions and additions to this manual in order to ensure electric power equipment of the Line 2A is appropriately maintained.

Such proposals and/or propositions presented to HQ shall be made in accordance with the regulation.

Materials:

Draft of Equipment maintenance manual
〈Line 2A station equipment〉

Implementer: Nguyen Viet Quan

JICA TA Team: Mr Takeshi Ikeda

November 30, 2015 in Hanoi

Contents

1. Plan of the Day (Form)

2. Monthly Maintenance Plan (Form)

3. Long-term Maintenance Plan (Form)

4. Budget Planning (Form)

F: Acceptance Inspection, Quality Evaluation and Monitoring after Work

G: Implementing Organization

1. Organizational Structure

2. Responsibility for Implementation

3. Revision and Additions

Attached Reference Materials

1. **Organizational Structure, Functions and Assignment of Maintenance Section at Headquarters (HQ) and in Field (OU)**
2. **Procedure for Calculating Necessary Number of OU Staff**
3. **Procedure for Calculating Costs of Required Maintenance Items (Including the guideline for creating the list of items that are to be managed in-house and the list of items to be outsourced)**
4. **Procedure for Creating Operational Plan relevant to Maintenance Work (Including the forms of the business plan and the update plan to be developed)**
5. **Guideline for Creating Staff Training and Education Plan**
6. **Criteria for Number of Units Installed**
7. **Provisions on Information Sharing**
8. **Guideline and Form for Creating Equipment Ledger**
9. **Ledger Form of Equipment Durable Years**

A: Legal Foundation

1. Laws and Rules

- Vietnam Railway Act 2005:
- Contents of this rule shall be compliant with the laws and rules of Vietnam. Currently, rules and standards concerning operation and maintenance of the urban railway are being prepared in Vietnam. After the above rules and standards are officially announced, we must update and recreate our rules in order to comply with them.

2. Relevant Materials

- Vietnam Railway Act 2005
- Circular No. 20/2013/TT-BGTVT dated 2013/8/16 on Management and Maintenance of Railway Structure.
- Circular No. 05/2015/TT-BGTVT dated 2015/3/30 on Standard for Operating Staff of Urban Railway.
- Circular No. 52/2014/TT-BCA on Management, Storage and Maintenance of Fire Extinguishing Means.
- Circular No. 07/2014/TT-BLĐTBXH on Announcement of Technological Safety Verification Process 27 of Machines and Equipment that are under the jurisdiction the Ministry of Labor, Disabled Veterans and Society, and are required to satisfy stringent safety requirements.
- Circular No.21/2015/TT-BGTVT on Working Hours and Break Time of Employees Who Engage in Specific Operations in Railway Transportation.
- Standard QCVN No. 08:2015/BGTVT on Railway Operation.

Standard QCVN No. 09:2010/BTTTT on Earth Connection at Communication Site.

- National Technical Standard QCVN No. 01:2008/ BCT on Electric Safety.
- Standard QCVN No. QĐT-5: 2009 on Verification of Facility of Electrical System.
- National Technical Standard QCVN No.02:2011/BLĐTBXH on Electric Elevators.
- National Technical Standard QCVN No. 11:2011/BLĐTBXH on Escalators and Conveyors for Carrying Humans.
- Escalator Safety Technology Verification Standard QTKD No. 002:2008/BLĐTBXH.
- Electric Elevator and Hydraulic Elevator Safety Technology Verification Standard QTKD No. 003:2008/BLĐTBXH.
- TCVN No. 8585:2011 on Urban Railway for Fast and Mass Transit - Vietnam Standard TCVN No. 3890 : 2009 on Houses and Structures Fire Extinguishing Means (Servicing, Arrangement, Inspection and Maintenance).
- Vietnam Standard No. TCVN 5760 on Requirements for General Technology used for Design, Installation and Use of Fire Extinguishing System.
- Vietnam Standard No. TCVN 5738 on Requirements for Technology used for Automatic Fire Alarm System.
- Vietnam Civil Engineering Work Standard No. 46:2007 on Design, Inspection and Maintenance Guide of Lightning Protection System for Civil Structures
- Vietnam Standard TCVN No. 5687:2011 on Design Standard of Air-conditioning and Ventilating System
- General Railway Structure Maintenance Standard TCCS No. 02:2014/VNRA

- Seamless Railway Structure Maintenance Standard TCCS No. 03:2014/VNRA
- Training Plan Ver 16.0 for the Line 2A (Cat Linh-Ha Dong)

Technology Design of the Line 2A (Cat Linh-Ha Dong) (Update of information regarding station equipment)

- Technology Design for Line 3 (Nhon-Ha Noi Station) Equipment (A French consultant)
- Technology Design for Line 2 (Nam Thang Long-Tran Hung Dao) Equipment (A Japanese consultant)
- Other Reference Material from TA Project

3. Purpose

The Station Equipment Maintenance Manual has been established in order to maintain the technical standard related to the equipment and also to help ensure stable operation of the station equipment by making sure that the maintenance staff's work practices and procedures are consistent with the rule.

4. Definition of Terms and Interpretation of Abbreviations

4.1 Definition of Terms

The term equipment denotes the communication equipment, signal equipment, electric power equipment and station equipment.

Communication equipment is the provision used to ensure safe operation and provide communication for passenger service.

Signal equipment consists of the interlocking device and the signal system that controls trains for the safe operation.

Electric power equipment is the provision that supplies power from a distribution board to each station's equipment and power to trains for travel from an electric power substation.

The electric room of a station is the room containing equipment that supplies power to station equipment.

The electric room of a depot is the room containing equipment that supplies power to depot equipment..

Station equipment refers to the equipment in a station that utilizes electricity excluding AFC equipment, communication equipment and signal equipment.

Equipment maintenance refers to work processes necessary to ensure and maintain normal operations of equipment as specified in the course of business transactions. Equipment maintenance work includes inspections, maintenance, repairs and quality verification of equipment.

Inspection means identifying the condition of equipment either by using intuition or by use of specialized tools in order to identify a failure or potential failure, and requesting recovery-related actions when a failure is detected.

Periodic inspections involve inspecting each item of equipment based on the cycle specified for them in order to maintain them in normal condition up to the next inspection.

Extraordinary inspection refers to an inspection other than the periodic inspection that takes place as needed in the wake of an accident, equipment modification or disaster.

Maintenance denotes the activities of monitoring, maintaining and repairing equipment on a continual or regular basis in order to ensure normal operation of each item of equipment and to reduce potential failures.

Repair is the activity of fixing failures that have occurred in the course of equipment operation to ensure safe railway operations. Repair comprises both periodic and extraordinary repair work.

Periodic repair refers to replacement of a section or part, or adjustment that is carried out on a regular basis according to the specified troubleshooting or maintenance procedure of each item of equipment.

Extraordinary repairs are carried out when a safe rail transportation is affected by an accident, transportation-related problem, disaster, etc.

Design quality validation inspects and validates the quality, and evaluates compliance of the given item of equipment with the relevant design requirements.

Maintenance staff denotes the Manager, Deputy Manager, Section Engineers, Leaders and workers at the Center.

The maintenance plan is a table that summarizes necessary maintenance work processes being planned in chronological order. The maintenance plan comprises the inspection plan, maintenance plan, repair plan and budget plan.

Patrol is the work of identifying environmental changes as well as the condition of equipment installed in a particular location that requires maintenance to help ensure equipment is managed appropriately and accidents are prevented.

The Equipment Inspection Standard Table contains the inspection items indispensable in the periodic inspection.

The Inspection Base Date refers to the day designated for the periodic inspection.

The Inspection Base Date Control Table is used to control the inspection base date for every item of equipment.

The Periodic Inspection Roadmap is a table that summarizes the longest inspection cycle set for each item of equipment in the equipment inspection standard table.

Monthly Workload Planning shows the maintenance work of a month in a table form.

Annual Workload Planning shows the maintenance work of a year in a table form.

Long-term Workload Planning shows the multi-year maintenance work in a table form.

Inspection Table is used to record results of the equipment inspection.

Work Instructions provide instructions necessary during equipment maintenance.

The operating Report is used to report the result of the completed equipment maintenance.

Equipment Maintenance Manual describes the procedures, precautions, manual work procedures, operation method, etc. necessary to carry out the equipment maintenance.

4.2 Abbreviations

HQ: Headquarters

OU (Operation Unit): Local companies

BGTVT: Ministry of Traffic and Transportation

BCA: Ministry of Public Safety

BCT: Ministry of Industry and Commerce

BLĐTBXH: Ministry of Industrial Injury and Society

ĐSĐT: Urban railway

QCVN: National Technical Criteria

TCVN: National Technical Standard

TCCS: Base Criteria

QTKĐ: Verification process

ATC: Automatic Train Control

ATO: Automatic Train Operation

ATS: Automatic Train Supervision

ATP: Automatic Train Protection

PAS: Public Address Systems

AWS: Automatic Warning System

....

5. List of Station Facilities

B: Requirements for Maintenance Facilities, Equipment and Staff

1. Requirements for Maintenance Facilities and Equipment

1.1. Requirements for Facilities

Create a list of facilities, devices and tools used to implement the maintenance process based on the specifications of the station equipment and the requirements for tools and devices. The above list becomes the basis of future maintenance work.

List of Facilities, Tools and Devices used for Maintenance of Station Equipment

Order	**Device name**	**Standard or specification**	**Intended purpose**	**Note**
1				
2				

1.2. Requirements for Equipment

Decide on the equipment specifications for future repair and maintenance based on the specifications of equipment providers.

Equipment Specification Table

Order	Equipment and system names	Specification	Note
1	Elevator	*As per equipment provider*	
2	Escalator	*As per equipment provider*	
3	Equipment of air conditioning and ventilation systems	*As per equipment provider*	
4	Lighting equipment	*As per equipment provider*	
5	Lightning protection system	*As per equipment provider*	
6	Fire alarm and detection equipment	*As per equipment provider*	
7	Feed-water and drainage equipment (pump, water pipe, etc.)	*As per equipment provider*	
8	....		

- Spare equipment shall be stored in a separate location. Their quantity and quality shall be warranted for use as needed.

1.3. Requirements for Maintenance Tools and Devices

- Maintenance tools, devices and facilities must be kept in good condition at all times.
- Special equipment for emergency purposes must be kept in a separate location, and clear indicative information and appropriate guidance must be attached.

2. Requirements for Maintenance Staff

2.1. Requirements for Number of Maintenance Staff

(How to calculate the number of necessary staff at HQ and OU: Based on the Line 2A education plan and the reference materials used in the TA project.)

2.1.1. The number of managerial staff computed based on the method used in calculating the number of necessary staff for the Line 2A

- The number depends on the workload and administrative abilities.

+ Managerial staff may directly carry out maintenance work.

+ In order to ensure quality of the maintenance work, managerial staff other than the Manager should carry out the work in three shifts.

+ Manager and Deputy Manager must support Section Engineers in implementing the maintenance work.

- Should be determined based on the workload of 12 stations (the Line 2A comprises 12 stations)
- The number should be determined based on the maintenance plan developed.

➔ When the business was started, six managerial staff were working at the Station Equipment Inspection and Repair Center of the Line 2A to ensure management and execution of the maintenance work. Its composition was a Manager, two Deputy Managers (one in charge of safety and the other in charge of operations), and three Section Engineers.

b. Number of workers

- The number depends on the equipment maintenance workload.
- The maintenance criteria of the Beijing Railway specifies 3.5 general inspection and repair workers per station and 01 elevator inspection and repair worker per station for each of 12 stations of the Line 2A.

➔ Therefore, 42 general inspection and repair workers (3.5 x 12) are necessary.

12 elevator inspection and repair workers (01 x 12) are required.

General inspection and repair workers are grouped into two teams and a Leader is assigned to each team. One team is in charge of maintenance of six stations and carries out the work over three shifts according to the shift table approved by the Manager. (The number of workers in a team varies depending on the workload and the number of equipment items subject to maintenance.)

- Elevator inspection and repair workers are grouped into two teams. A team, consisting of a Leader and five workers, carries out elevator maintenance at six stations. According to the system, 2/3 out of the three shifts carries out the work.

2.1.2. For reference when calculating the number of other staff

- The HQ and OU staff number calculation method and shift table created by the specialist in the TA project and C/P (Attached material)

2.2. Requirements for Capacity and Skill Level of each Duty Position at Inspection and Repair Center

2.2.1. The Manager of OU assumes total responsibility for all operations performed at the Center, and is responsible for providing guidance to Center employees to ensure they implement the allotted assignments. The Manager is responsible for all operations including those related to safety, service, emergency inspections and repairs, as well as cultural establishment. Therefore, the Manager of OU must meet the following requirements.

- Has a college education or above, and expert knowledge on station equipment management.
- Has more than three years of experience in the station equipment management.
- Is knowledgeable in the applicable laws and rules, and complies with the rules of the organization.
- Has the ability to improve oneself via study, a good imagination, and the ability to be diplomatic when negotiating, and has sufficient decision-making abilities.
- Has a certificate of health proving that they satisfy the health standard set by the Ministry of Medical Services.

2.2.2. The Deputy Manager in charge of safety shall assist the Manager of OU in executing the Center's operations and assume the responsibility in managing the safety-related assignment. Therefore, the Deputy Manager in charge of safety at the Station Equipment Inspection and Repair Center must meet the following requirements.

- Has a college education or above, and expert knowledge on station equipment management.
- Has more than two years of experience in the station equipment management.
- Is knowledgeable in the applicable laws and rules, and complies with the rules of the organization.
- Has the ability to improve oneself via study, a good imagination, and the ability to be diplomatic when negotiating.

2.2.3. The Deputy Manager in charge of operation shall assist the Manager of OU in executing the Center's operations and assume the responsibility mainly in the production sector. Therefore, the Deputy Manager in charge of operation at the Station Equipment Inspection and Repair Center must meet the following requirements.

- Has a college education or above, and expert knowledge on station equipment management.
- Has more than two years of experience in the station equipment management.
- Is knowledgeable in the applicable laws and rules, and complies with the rules of the organization.
- Has the ability to improve oneself via study, a good imagination, and the ability to be diplomatic when negotiating.

2.2.4. The Section Engineer assumes responsibility for managing the technology used for the station elevators and other equipment, handling failures, and implementing recovery measures in the case of urgent accidents. Therefore, the Section Engineer must meet the following requirements.

- Has a college education or above
- Has expert knowledge about the principles of the station equipment system, understands the technical processes, technical standard and recovery measures in the case of urgent accidents, and a high degree of skill in handing software for office use as well as sophisticated special software such as CAD.
- Has the ability to improve oneself via study, a good imagination, and the ability to be diplomatic when negotiating.

2.2.5. The general inspection and repair worker is responsible for implementing respective phases of maintenance for each item of equipment except elevators according to the rules and procedures specified by the company, and is also responsible for rescuing passengers rapidly and directly should an accident or failure occur. Therefore, the worker must meet the following requirements.

- Has a high school education or above
- Has generic knowledge about station equipment or specialist knowledge in the relevant area.
- Has the ability to improve oneself via study, a good imagination, and complies with organization rules.

2.2.6. Elevator inspection and repair workers have the responsibility of implementing elevator maintenance work according to the rules and procedures specified by the law or company, and directly implementing emergency measures should an accident occur. Therefore, elevator inspection and repair worker must meet the following requirements.

- Has a high school education or above
- Is legally qualified to carry out elevator maintenance and possesses the relevant certificate.
- Has the ability to improve oneself via study, a good imagination, and complies with organization rules.

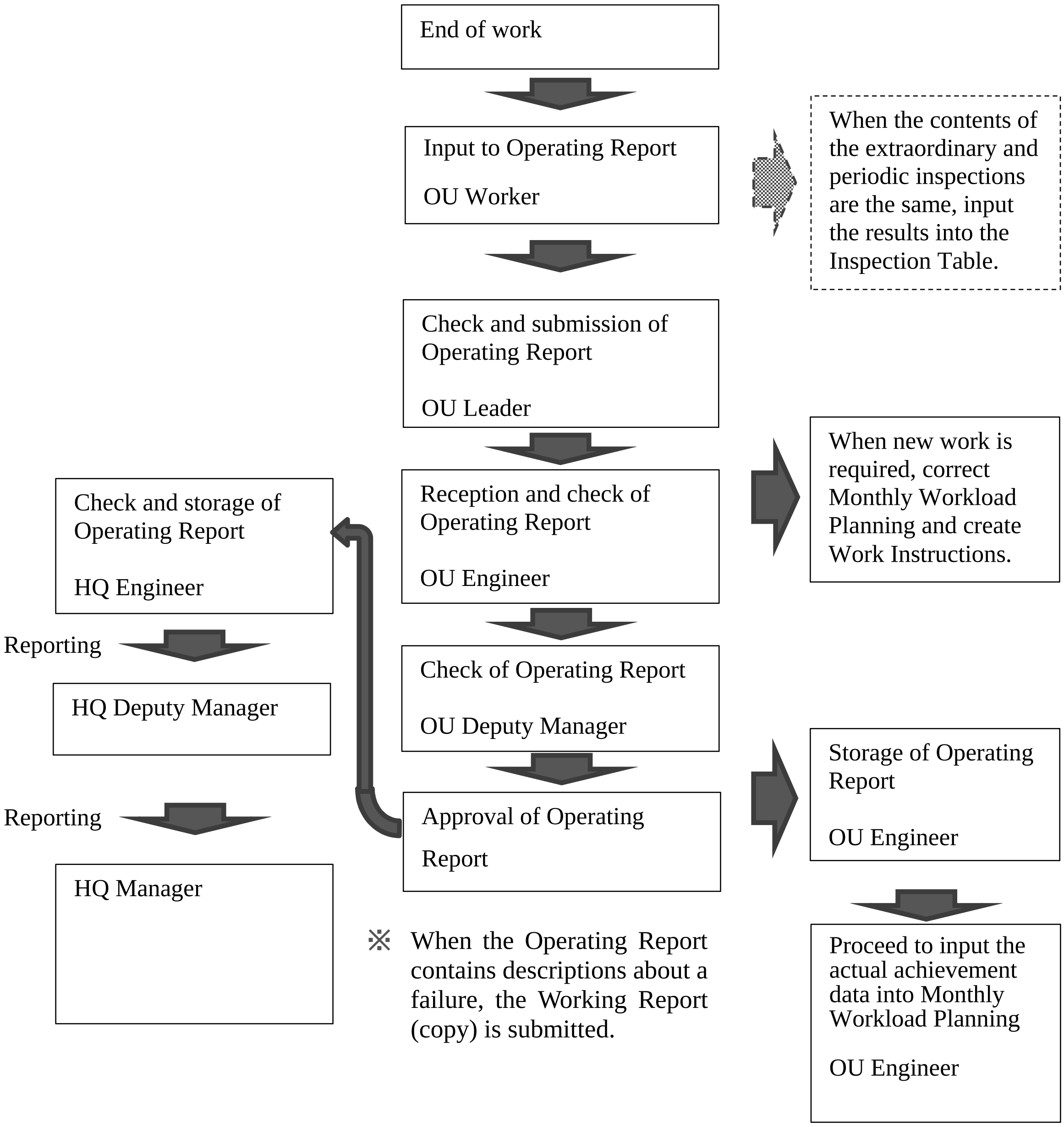
C: Classification of Maintenance Operations and Work Implementation Flow

1. Classification of Maintenance Operations

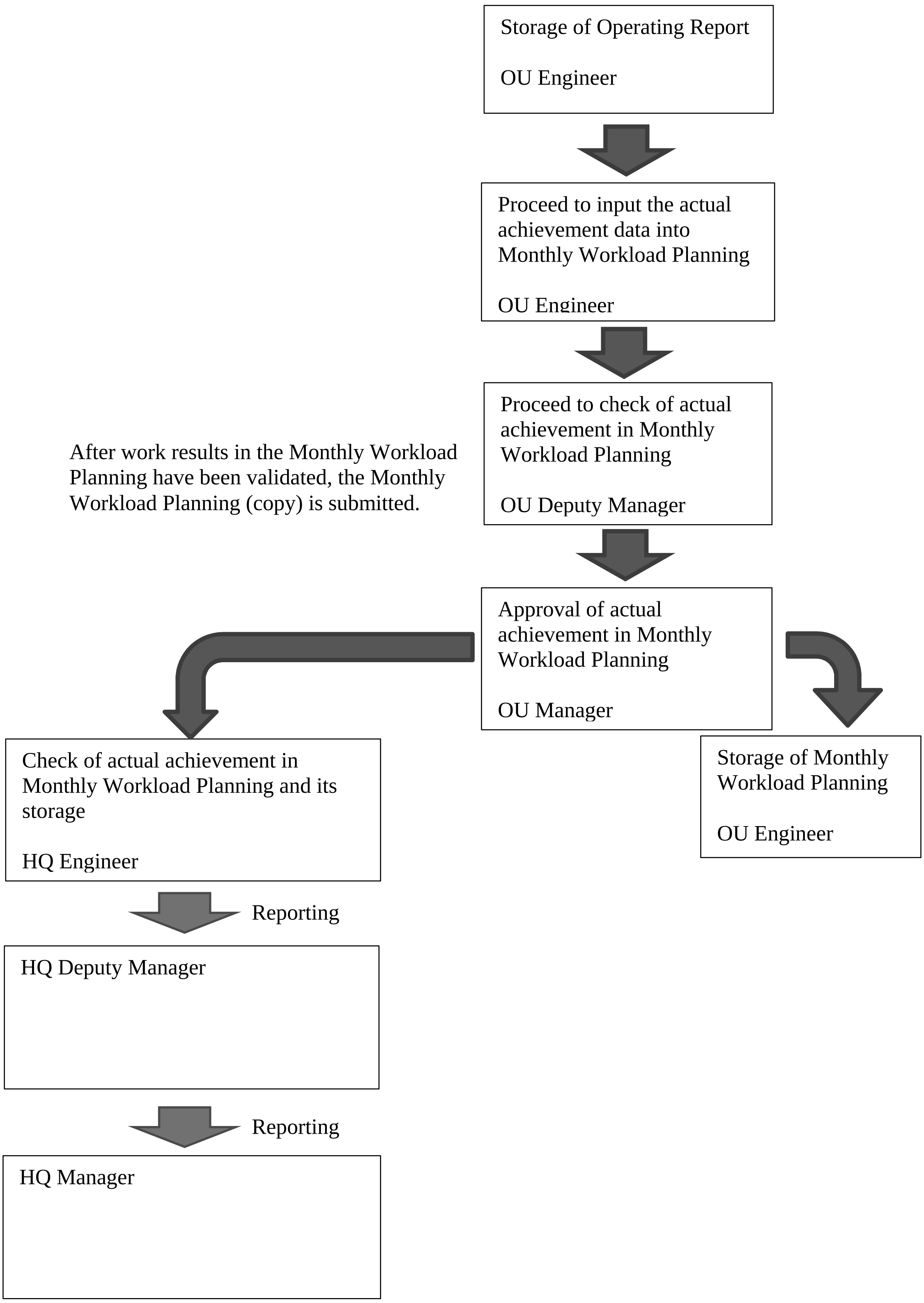
- Equipment maintenance work must include the inspection, maintenance, repairs and quality verification of the equipment.
- The equipment inspection must include a periodic inspection and an extraordinary inspection. The equipment inspection must include an overall inspection and a detailed inspection.
- Equipment repair work must include periodic repairs and extraordinary repairs.

2. Work Implementation Flow

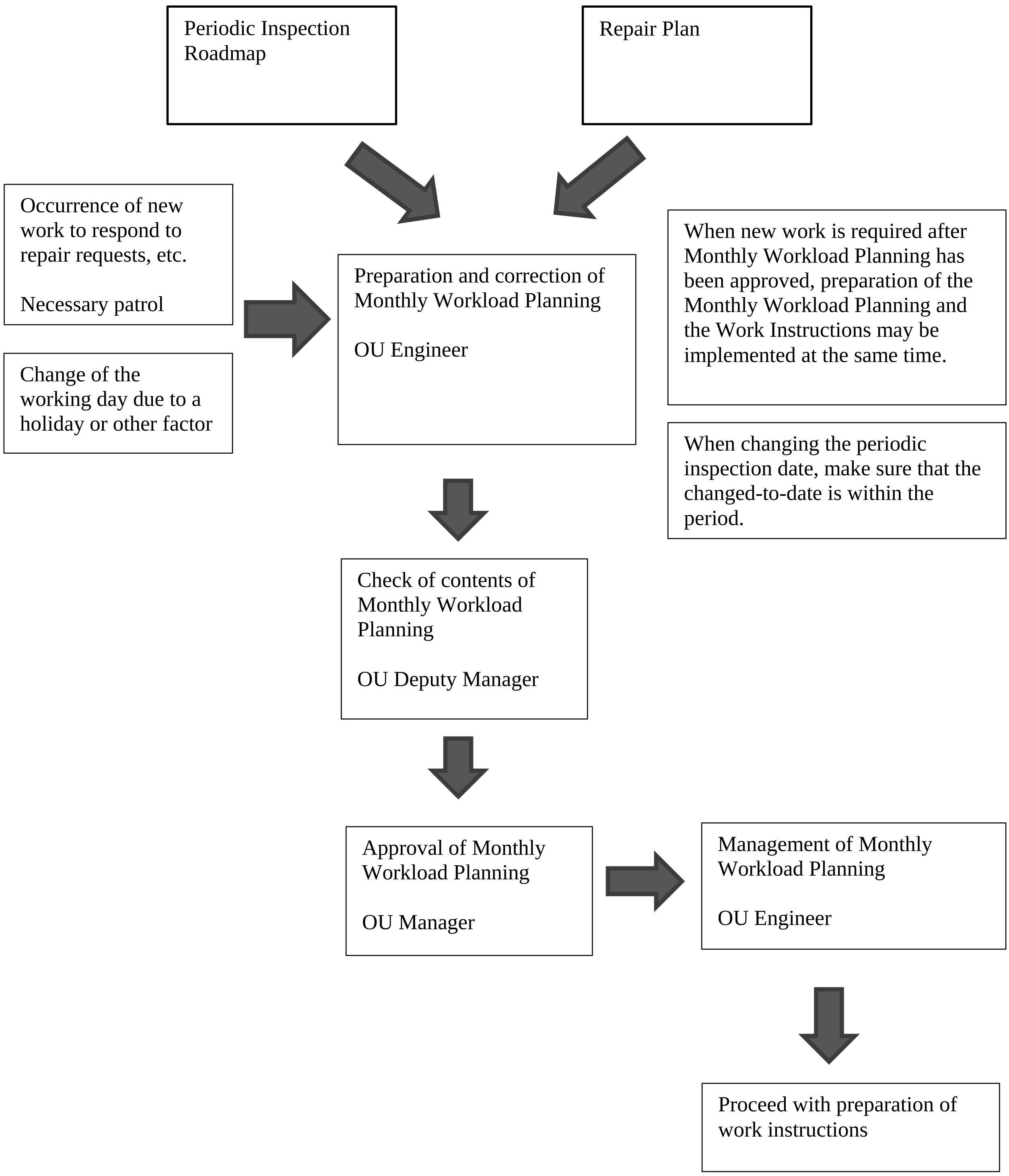
2.1. Operating Report Preparation Flow



2.2. Flow of Entry of Actual Achievement to Monthly Workload Planning



2.3. Monthly Workload Planning Preparation Flow



2.4. Work Instructions Preparation Flow

Monthly Workload Planning

Implementation of new work to respond to repair requests, etc.

Due to a change of scene, etc.
Change of planned work

Preparation and correction of Work Instructions

OU Engineer

Check of Work Instructions

OU Deputy Manager

When new work is required after Monthly Workload Planning has been approved, preparation of the Monthly Workload Planning and the Work Instructions may be implemented at the same time.

Approval of Work Instructions

OU Manager

Operating instructions based on Work Instructions

OU Engineer

Preparations for and implementation of work

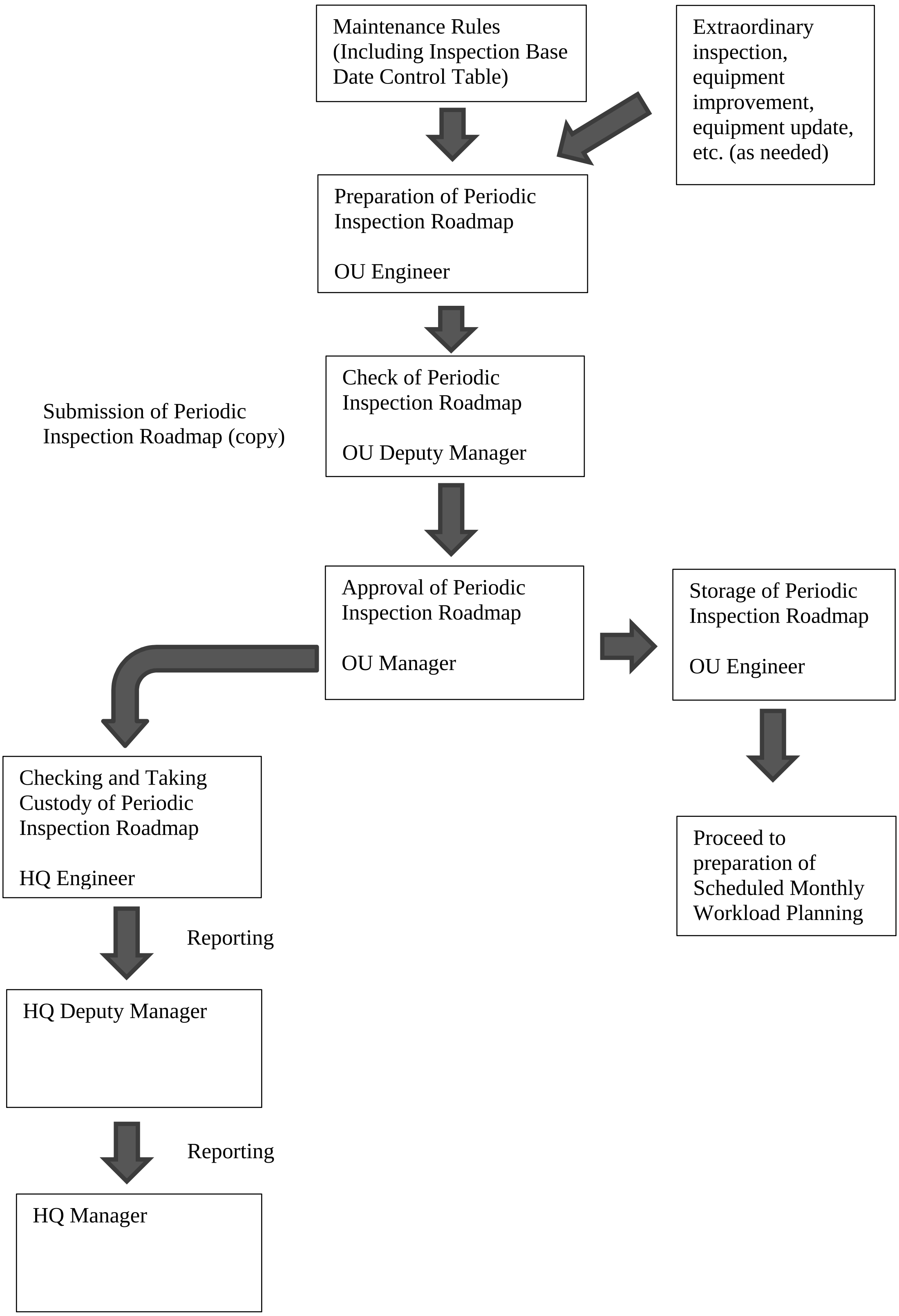
OU Leader and worker

End of work

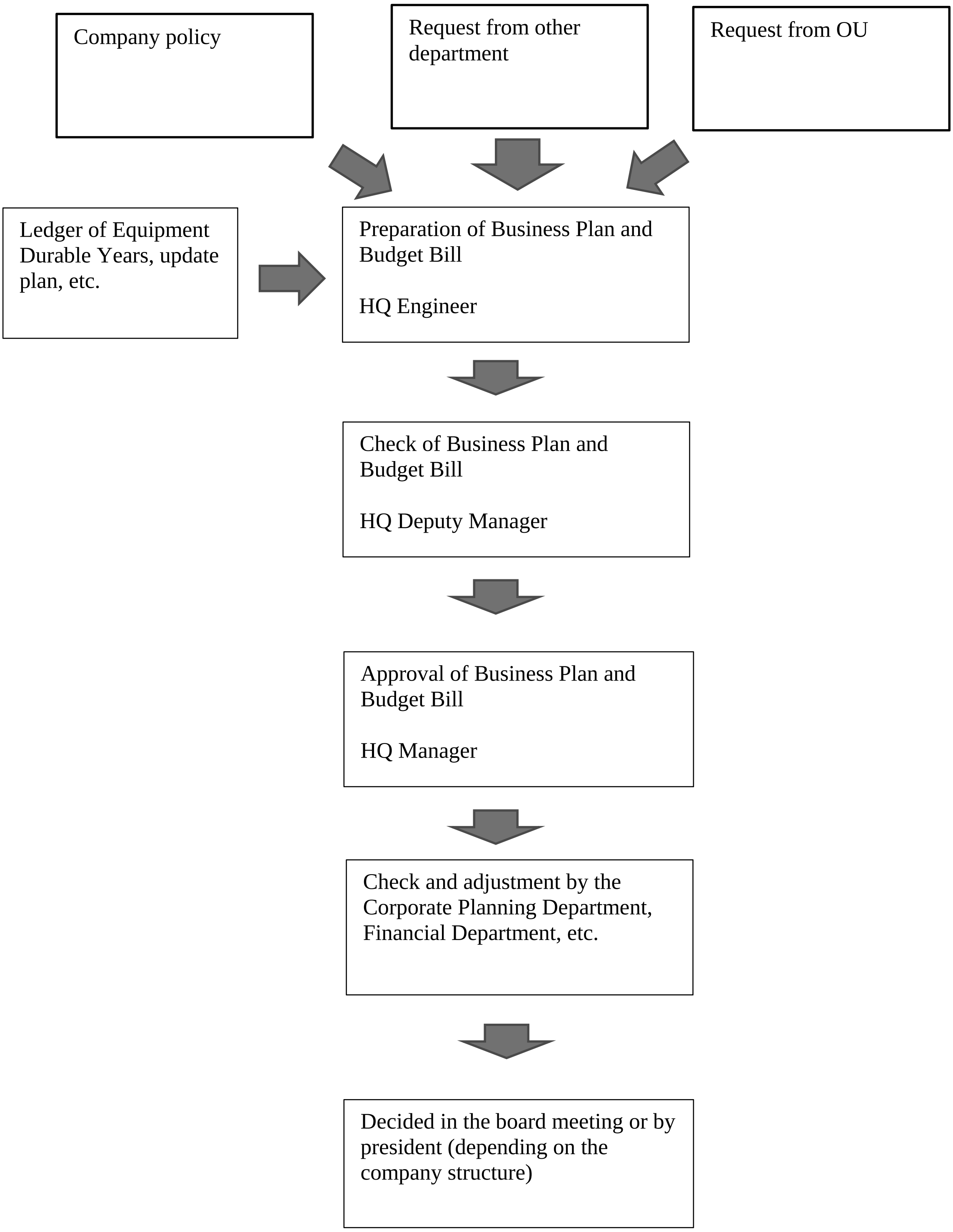
OU Leader and worker

Proceed to preparation of Operating Report

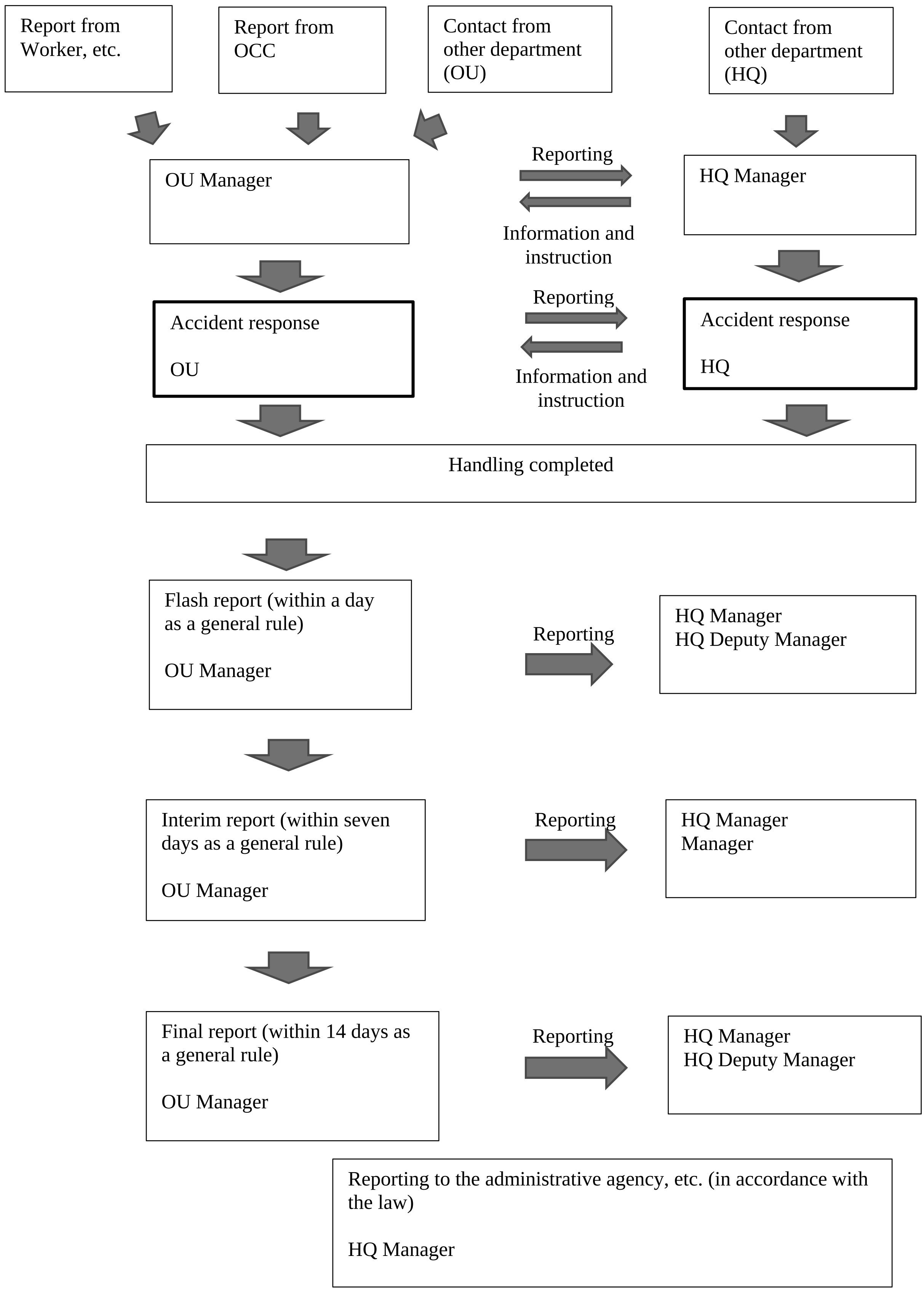
2.5. Periodic Inspection Roadmap (Long Term) Preparation Flow



2.6. Business Plan and Budget Preparation Flow



2.7. Flow of Response to Accidents and Transport Disorders



D: Survey Measurement and Validation of Equipment Condition

1. Installation Location

- Inspect appropriateness of the equipment referencing the working and design drawings.
- Be sure to inspect and measure the installation location based on the provisions and procedures described in the approved Work Instructions.

2. Validation of Equipment Operating Status

2.1. Overall Inspection of Equipment

- Acceptability of the operating status
- Acceptability of the installed condition
- Check whether a problem resulted from environment, weather, etc.
- Check presence or absence of stains, damages, etc.
- Check presence or absence of abnormal odors, noises, etc.

2.2. Detailed Equipment Inspection

Order	Equipment name	Contents of inspection *(For reference only)*	Inspection cycle	Note
1	Equipment of air conditioning and ventilation systems	1. Operating rate of equipment 2. Operating status of heating device and motor 3. Operating status of fan of cooling device 4. Operating status of fan for change of direction 5. Appropriateness of voltage	Check them once a year or as many as suggested by the provider.	
2	Elevator	1. Distribution board and hoisting machine 2. Balance between elevator car and weight 3. Elevator door 4. Pit 5. Elevator car door 6. Test run	Twice a year or as many as suggested by the provider.	
3	Escalator	1. Distribution board and hoisting machine 2. Control board 3. Intermediate place 4. Exterior 5. Test run	Twice a year or as many as suggested by the provider.	
4	Feed-water and drainage equipment (pump, water pipe, etc.)	- According to the rule of, or suggestion from, the provider.	According to suggestion by provider.	
5	Lighting equipment	- According to the rule of, or suggestion from, the provider.	According to suggestion by provider.	
6	Lightning protection system	1. Acceptability of wiring of distribution lines. 2. Suitability of earth resistance value. 3. Presence or absence of evidence of wear.	Once a year at minimum (According to	

		4. Presence or absence of influence of structural change of a station to the lightning protection system.	the Vietnam Civil Engineering Work Standard TCXDVN No.46: 2007).	
7	Fire alarm and detection equipment	- According to the rule of, or suggestion from, the provider.	Twice a year (According to TT52/2014/TT-BCA)	
8	....			

E: Preparation of Plan *(Request for plan and format preparation)*

1. Plan of the Day (List the maintenance items of the day according to the Monthly Maintenance Plan)

1.1. Work Instructions

<table>
<tr><td rowspan="2">Work Instructions</td><td rowspan="2">Date and time
(Work implementation time specified in the Work Instructions)

Station Equipment Inspection and Repair Center: the Line 2A</td><td>OU Manager
(Approver)</td><td>OU Deputy Manager
(Checker)</td><td>OU Engineer
(Preparer)</td></tr>
<tr><td>(Signature)</td><td>(Signature)</td><td>(Signature)</td></tr>
<tr><td>Time when a failure detected
(Describe date and time in detail)</td><td>Year __ Month __ Day __ Hour __</td><td>Requested by

(Signature)</td><td colspan="2">Including the reason why the failure was detected
Station, alarm, periodic inspection, patrol and other</td></tr>
<tr><td>Location and equipment name</td><td></td><td>Work code
(When provided)</td><td colspan="2"></td></tr>
<tr><td>Work name</td><td colspan="4"></td></tr>
<tr><td colspan="5">Contents of instruction (What, how, by when, current situation, drawings, etc.)</td></tr>
<tr><td colspan="5"></td></tr>
<tr><td colspan="5"></td></tr>
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<tr><td colspan="5"></td></tr>
<tr><td colspan="5"></td></tr>
<tr><td colspan="5">Precautions for work (A special location, requirements, precautions for work)</td></tr>
<tr><td colspan="5">1</td></tr>
<tr><td colspan="5">2</td></tr>
</table>

1.2. Operating Report

Working hours	Day/ Night	Materials used (To be clearly indicated in the instructions)	Available/ Unavailable	Arrangement Date	Receipt of material
Operating Report				Date repair completed	Date	Reported by (Signature of Leader)

	OU Manager	OU Deputy Manager	OU Engineer
Confirmation of completion			

Correction of records in Inspection Table	Input to Monthly Failure Report	Correction of maintenance drawing	Correction of Equipment Ledger	Input to Shipping/Receiving Card
Yes/No/Finished	Yes/No/Finished	Yes/No/Finished	Yes/No/Finished	Yes/No/Finished

Date	Name of worker	Contents of work (Survey, Treatment, Result, Materials used, and Hand-off)	Check by OU Deputy Manager (When work of the shift is not completed)

Cause, treatment, comments	
	Model of removed item
	Model of installed item
	Serial number of removed item
	Serial number of installed item
	Date of manufacturing of removed item
	Date of manufacturing of installed item
	Name of manufacturer of removed item
	Name of manufacturer of installed item

Necessity for request of special repair (When approval of HQ Station Equipment Section is necessary)	Necessary / Not necessary

2. Monthly Maintenance Plan (Form)

<table>
<tr><td colspan="2" rowspan="2">Revision history</td><td colspan="4" rowspan="2">Year _ Month _ Workload Planning
Department: Station Equipment Inspection and Repair Center</td><td colspan="3">Hanoi Metro Company
The Line 2A</td></tr>
<tr><td>Plan

(Signature)</td><td>Actual achievement

(Signature)</td><td>Note</td></tr>
<tr><td rowspan="2">Day</td><td rowspan="2">Month</td><td colspan="3">Contents of inspection</td><td>Location of inspection</td><td></td><td></td><td rowspan="17"><On Addition of and Change in Work>
(1) When there was an addition or change in the scheduled work, describe it in the table using a pencil.
(2) When an addition work is completed, indicate it using a red pencil.
Connect the work before and after it with an arrow.
(3) Select the applicable reason for the change from the following and write its number near the arrow.
"List of reasons of addition or change"
1. Because of a change in the</td></tr>
<tr><td>Shift 1</td><td>Shift 2</td><td>Shift 3</td><td></td><td></td><td></td></tr>
<tr><td>1</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
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<tr><td>15</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table>

.....								working schedule due to a holiday or other factors. 2. Because of the influence of an addition or change in other work. 3. Because of an accident or disaster. 4. Because of the convenience of the business partner. 5. Because of addition of all-night feed 6. Because of equipment failure. 7. Because of an extraordinary inspection due to equipment failure or other factor. 8. Because the work was added after the scheduled job was completed. 9. Other reason (Describe it clearly and in an easy-to-understand manner) <On actual achievement of work> (1) When the scheduled work was implemented, affix a “Completed” seal next to the end of the name of the work. (2) When work that was added or
30								
31								

								changed is completed, affix a "Completed" seal to the portion furnished with rubrics after the change.

3. Long-term Maintenance Plan (Form)

Sheet number/ Total number of sheets	Periodic Maintenance Plan					Hanoi Metro Company												
						Route: 2A												
Maintenance type	Equipment name	Contents of inspection	Inspection code	Inspection period	Location of inspection	(Year)												(Year)
						January	February	March	April	May	June	July	August	September	October	November	December	
Inspection																		
......																		
Maintenance																		
....																		
Repair																		
......																		

- Long-term Maintenance Plan may be created for the periods of one year, five years, 10 years and 30 years.

4. Budget Planning (Form)

Maintenance Budget Planning - Year __

Department: Station Equipment Section

Sheet number/Total number of sheets Route: the Line 2A

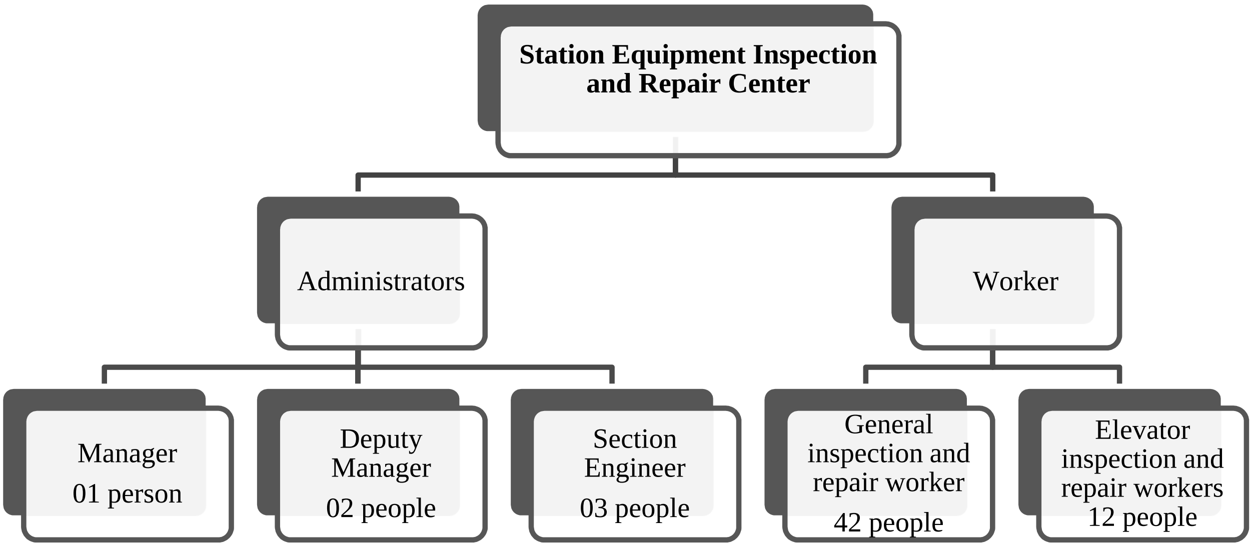
Maintenance time		**Contents of work**	**Method of implementation**	**Equipment use period**	**Maintenance cycle**	**Durable years**	**Total implementation cost**	**Cost breakdown**	**Note**
Month	**Day**								

F: Acceptance Inspection, Quality Evaluation and Monitoring after Work

- The above should be implemented based on the equipment specification submitted by the provider.
- The above should be implemented according to the work procedure and implementation processes specified by the law or company.

G: Implementing Organization

1. Organizational Structure



2. Responsibility for Implementation

- The Manager shall be responsible for creating and administering the plan, determining how to execute the plan, and instructing staff on how to cope with contingency situations, such as accidents.
- The Deputy Manager in charge of safety shall be responsible for developing the safety-related plan, instructing staff on how to implement safety inspections of equipment, goods and tools in order to maintain and manage them, and initiating emergency responses in the case of accidents, as well as assigning staff at the site as appropriate.
- The Deputy Manager in charge of operations shall be responsible for developing the equipment operation plan, inspecting and confirming the equipment functions, instructing staff on how to create the center's maintenance budget, and teaching staff how to take emergency initiatives in response to accidents that occur at the site in cooperation with others.
- The Section Engineer shall be responsible for developing the plan for the specialized area in his charge, creating work rules and guidelines, developing the equipment maintenance and management plan, and developing emergency response measures in case of an accident.
- The Leader shall be responsible for instructing and providing guidance to workers during maintenance work, reporting the result of maintenance work directly to the supervisor, and directly initiating emergency responses in the case of accidents.

- General inspection and repair workers shall be responsible for maintaining the equipment (except elevators) according to the rules and procedures specified by the law or company, and directly initiating emergency responses in the case of accidents.
- The elevator inspection and repair worker shall be responsible for implementing the elevator maintenance work according to the rules and procedures specified by the law or company, and directly initiating emergency responses in the case of accidents.

3. Revision and Additions

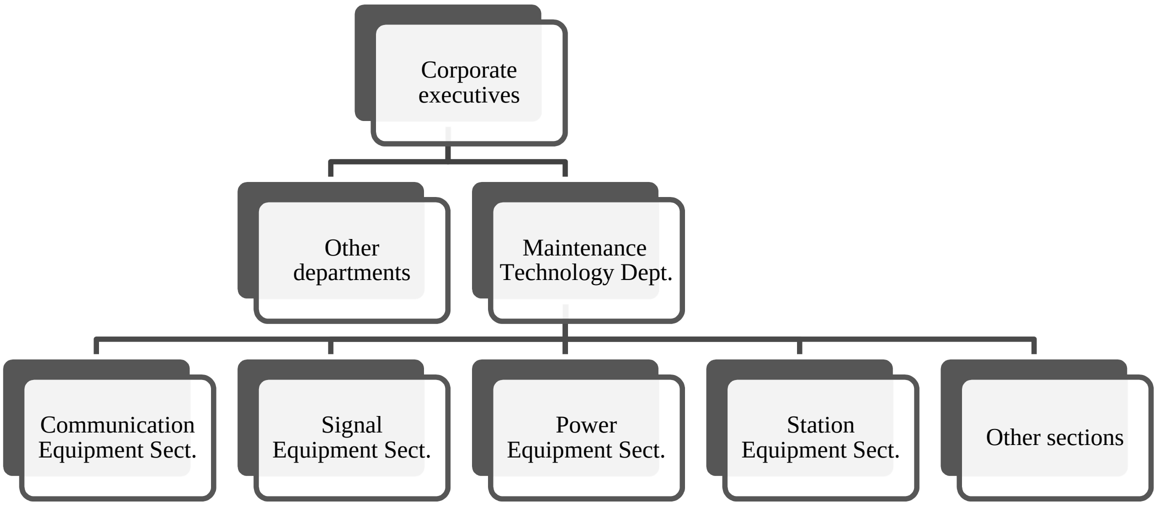
The Manager of the Station Equipment Inspection and Repair Center has the right to make proposals and/or propositions with regard to revisions and additions to this manual in order to ensure appropriate maintenance of station equipment is carried out on the Line 2A.

Such proposals and/or propositions presented to HQ shall be made in accordance with the rule.

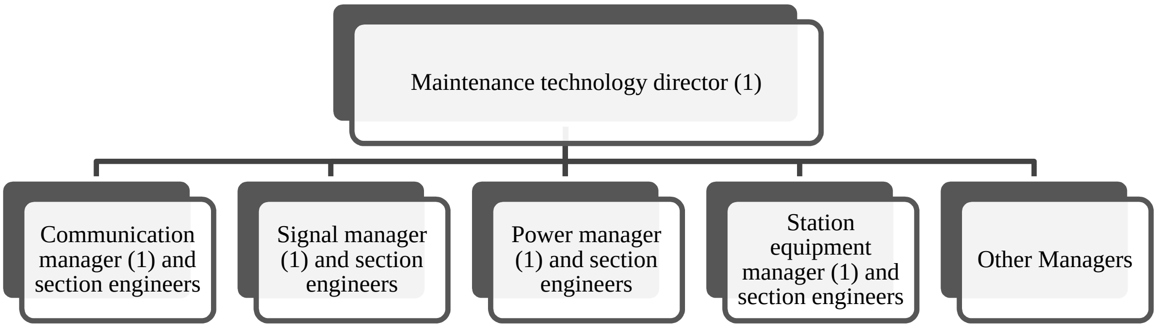
Organizational structure and operation/functions of the equipment sections in the Headquarters (HQ) and the Operation Unit (OU)

1. Organizational structure

1.1. Organizational structure of the company

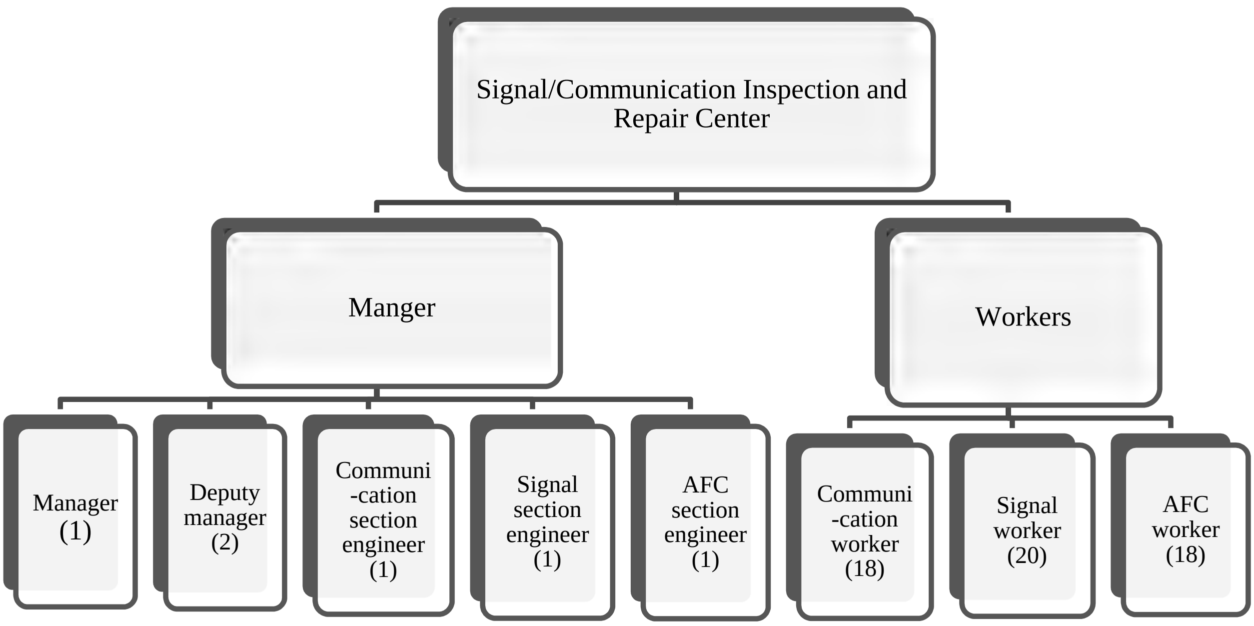


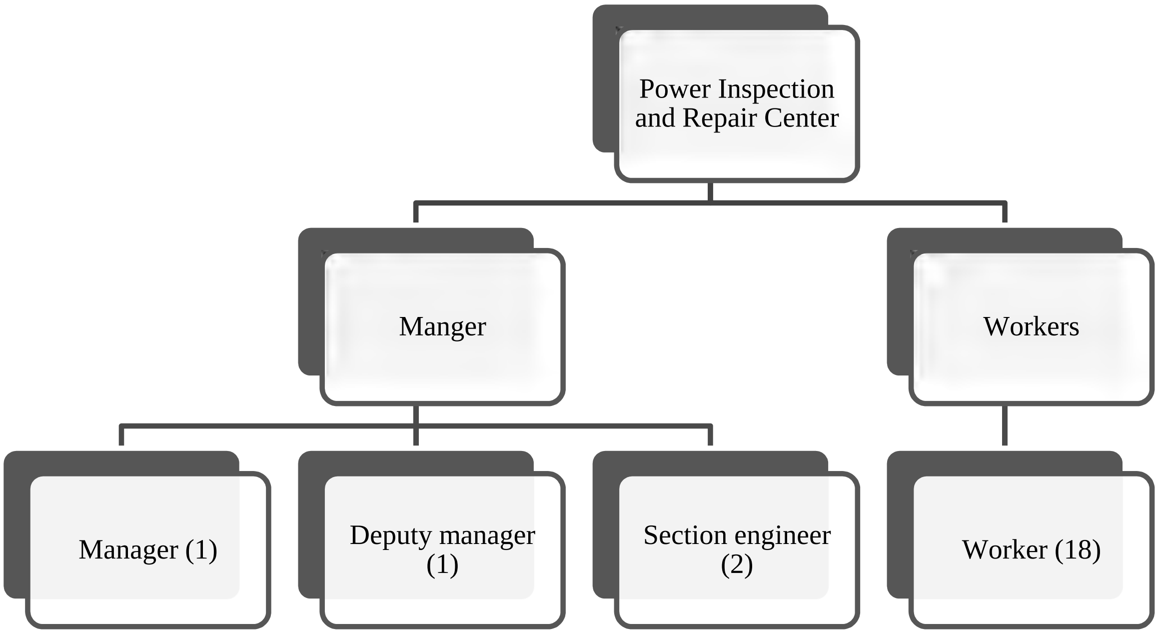
1.2. Organizational structure of the equipment sections of the Headquarters (HQ)

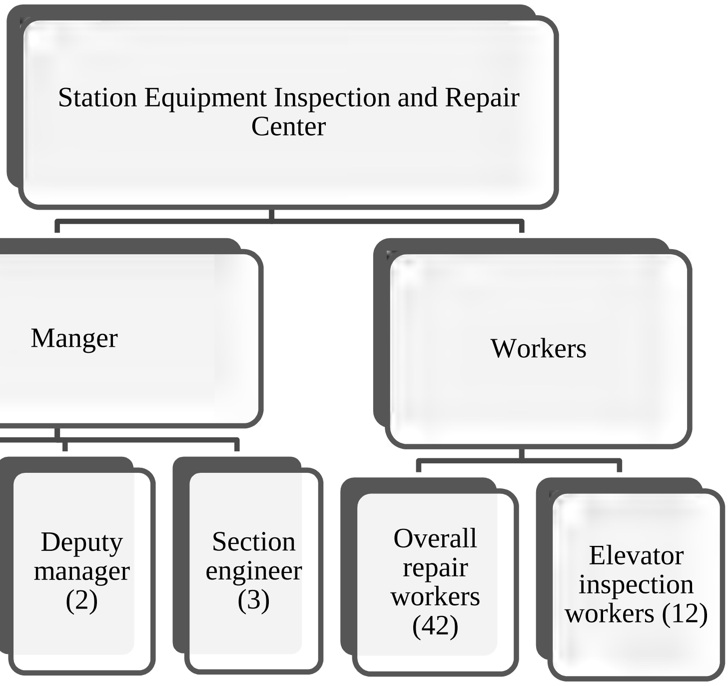


1.3. Organizational structure of the Operation Unit (OU)

OU under the control of the equipment sections consists of the signal/communication inspection and repair center, the power inspection and repair center, and the station equipment inspection and repair center.







2. Operation/functions of the equipment sections

2.1. Operation/functions of the HQ equipment sections

(a) Functions: The sections possess management functions for maintenance, replacement, and updating of equipment; they also give out advice to corporate executives and implement these functions (including signal communication, power, and station equipment).

(b) Operation:

1) Inspect plans on maintenance, replacement, and updating of equipment, training plans, and related procedures submitted by OU, with reference to related standards specified for each line.
2) Strike a deal with supervisory authorities concerning business under their control and make application for approval (including submission to the presidential meeting for approval).
3) Manage consignment contracts on maintenance, replacement, and updating of equipment and put them out to tender.
4) Sort out and formulate equipment maintenance rules.
5) Compile and adjust plans for maintenance, replacement, and updating of equipment.
6) Formulate steps and procedures of maintenance, replacement, and updating of equipment.

7) Supervise, inspect, assess, and manage work for maintenance, replacement, and updating of equipment OU is to undertake.
8) Cooperate with OU and other divisions in HQ so as to prevent and investigate accidents and make reports on them.
9) Collect data on accidents to analyze them, inspect related technologies, and formulate accident handling procedures in cooperation with OU.
10) Formulate plans concerning power demand.
11) Inspect budgets on costs and values related to repair, maintenance, and updating of equipment.
12) Adjust and manage work in response to requests for material supply and also in terms of use of parts in each line.
13) Manage and transfer maintenance personnel for each line in response to request based on human resource development plans.
14) Carry out work in its charge through cooperation with related departments.
15) Carry out other work that higher-ranking persons have taken their share of.

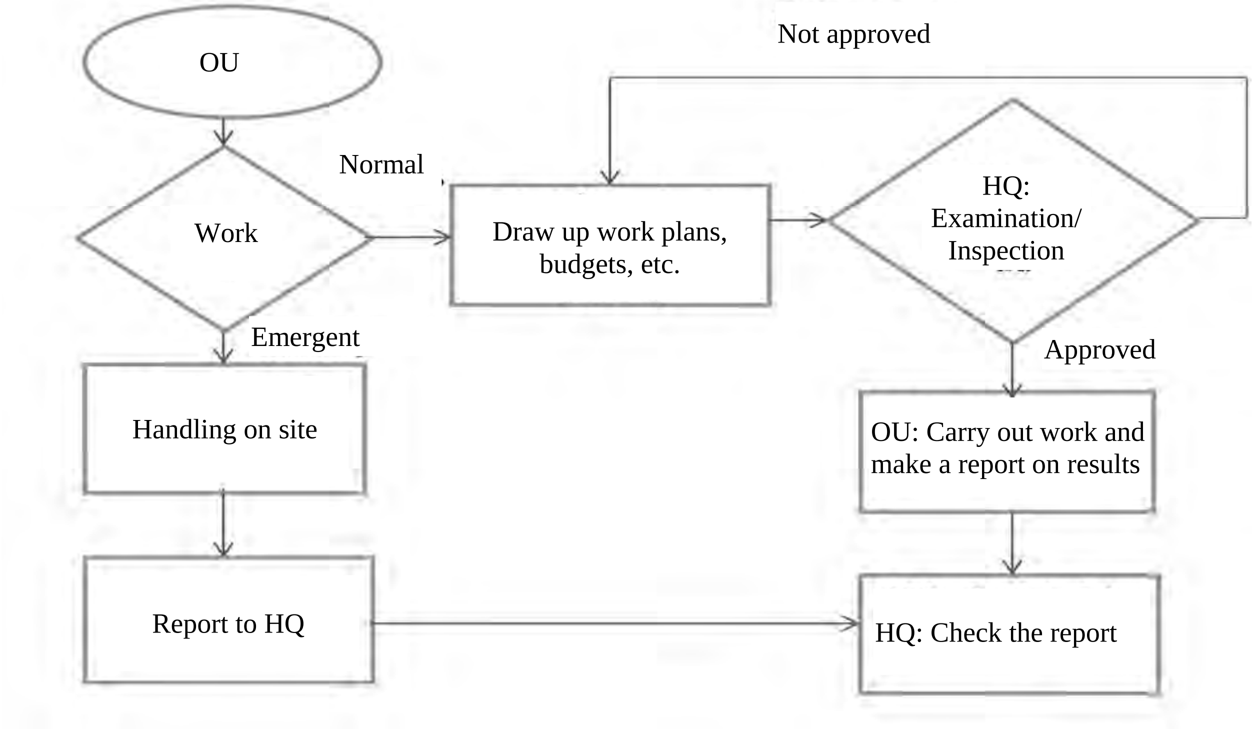
2.2. Operation/functions of the OU equipment sections

(a) Functions: OU is responsible for directly carrying out work for maintenance, replacement, and repair of equipment subject to rules and procedures specified by the company.

(b) Operation:

1) Draw up detailed maintenance plans of equipment under control of OU.
2) Draw up lists of equipment to be maintained, replaced or updated, and make up related budgets.
3) Formulate manuals for maintenance, updating, and repair of equipment in a line at issue.
4) Formulate work deployment plans for operation under its control.
5) Formulate plans related to power demand arising in line operation processes.
6) Formulate detailed plans concerning demand for replacement, updating, repair, and improvement of equipment.
7) Formulate plans and schedules for personnel in charge of maintenance, repair, and updating of equipment.
8) Prevent, investigate, and handle accidents related to operation under its control, and make reports on them.
9) Collect data on accidents to analyze them and improve equipment functions.
10) Formulate plans of maintenance and periodical updating of equipment.
11) Set tender prices and work out consignment contracts concerning equipment maintenance, improvement, and updating.
12) Formulate and complete equipment maintenance rules.
13) Carry out work in its charge through cooperation with related departments.
14) Formulate plans of education and training of equipment maintenance personnel.
15) Carry out other work that higher-ranking persons have taken partial charge of.

3. Relationship between the HQ and OU equipment sections.



4. Roles, responsibilities, and competence of each position in the HQ equipment sections
(Material attached)
5. Roles, responsibilities, and competence of each position in the OU equipment sections
(Material attached)

Roles, responsibilities, and competence of each job duty for the equipment sections of HQ

Manager	Deputy Manager	Section Engineer (in charge of a field of signal, communication, power or station equipment)
(1) Take a responsibility to manage work assigned to the section in a comprehensive manner, have employees in the section share job duty, and carry out all the work assigned to the section. (2) Take the responsibility for issuing instructions on, and managing formulation of, each plan of the section and implementing it. (3) Take the responsibility for formulating, inspecting, and completing equipment technical standards, operation procedures, and maintenance rules, and further for supervising, inspecting, and giving guidance on implementation conditions of them. (4) Take the responsibility for periodically performing analytical and statistical work on conditions of equipment management and operation maintenance, and also for supervising, giving guidance on, and inspecting adjustment work toward solution of problems that arise in operation processes. (5) Take the responsibility for following up domestic and overseas equipment development conditions; pursuing and studying new technologies, objectivity codes, and equipment management methods; and improving ceaselessly his/her own ability and operation quality of equipment. (6) Take the responsibility for organizing formulation work of outsourcing contracts related to equipment maintenance; getting engaged in negotiations on consignment contracts with subcontractors; auditing contract fulfillment; and adjusting relationships with consigned businesses. (7) Take the responsibility for adjustment and cooperation in order to respond to emergency situations on site, recovery from accidents during operation time, and sudden accidents/incidents. Also take the responsibility for investigating quality problems and implementing security measures.	(1) Support the manager in deployment of business assigned to the section. (2) Take the responsibility for studying technical standards concerning equipment management to be implemented based on corporate decision; collecting and grasping information related to railway equipment management; and studying and exploring new models concerning equipment operation and maintenance. (3) Take the responsibility for issuing instructions on and managing preparation and completion of related maintenance quality standards as well as other standards, rules, and institutions concerning equipment management, and further for observing, promoting, guiding, and inspecting preparation and completion of standards, rules and institutions related to the organization he or she belongs to. (4) Take the responsibility for issuing instructions and guidance on statistical/analytical work on conditions of equipment operation and maintenance, and giving out advice for solutions of problems that arise in operation processes. (5) Take the responsibility for reviewing projects for technological improvement, scientific and technological research, remodeling or updating of equipment, and major repairs. Simultaneously, also observe, manage, and inspect project implementation processes; issue instructions and guidance on acceptance validation (or a completion test) of remodeling work; and give guidance on appraisement (inspection with professional methods) and acceptance validation of each project. (6) Supervise, promote, give guidance on, and manage plans of outsourced equipment maintenance and implementation status of these plans, and also instruct and manage personnel in charge of implementation of outsourced maintenance contracts.	(1) Sort out and complete standards, rules and institutions concerning equipment each engineer is in charge of, and submit applications for approval to the manager. (2) Take the responsibility for guiding and inspecting the status of OU in implementation of contracts and compliance to related rules and procedures. (3) Analyze periodically technological conditions of equipment, and then instruct and guide OU to analyze and address accidents that occur frequently in equipment each engineer is in charge of and difficult problems related to technology. (4) Make database of equipment failures and accidents, and prepare statistics and analysis for equipment technical standards. (5) According to equipment conditions, issue a request on outsourcing of equipment maintenance, formulate outsourcing contracts, take part in contract negotiations and conclusions, and check implementation status of subcontractors. (6) Take the responsibility for formulating maintenance rules, taking part in drawing up and completion of maintenance manuals of equipment each engineer is in charge of, and participating in negotiations of equipment improvement contracts. Take the responsibility for compiling reports; contacting parties concerned for equipment design; inspecting equipment that has been improved; performing adjustment and acceptance validation (completion tests) of equipment; and issuing instructions and guidance on delivery of equipment. (7) Take the responsibility for guiding OU on deployment of technology updating and expansion of new technological introduction. (8) Take part in reviewing and reporting of each project concerning equipment, and yearly perform inspection of implementation status of technology improvement projects and make acceptance validation of them. (9) Take the responsibility for supervising, promoting and inspecting implementation status of employees, inspecting equipment for rescue and rescue measures, and taking part in training for emergency. (10) Take part in analytical surveys on failures, accidents, etc. and confirm and sum up results of expert research and analysis of accident causes.

(8) Take the responsibility for controlling budgets for maintenance, updating, and remodeling of equipment, and for reducing costs of operation management and maintenance by leveraging new management measures and technological countermeasures. (9) Take the responsibility for building good relationships with corporate executives, other sections and departments, and the personnel belonging to his/her section, and adjusting relationships with other sections and departments. (10) Take the responsibility for structuring his/her section, developing ability of employees, and promoting and inspecting work performance of the employees belonging to the section.	(7) In order for the section to carry out business, support the manager, train and develop ability of employees, and promote and inspect implementation status of work done by employees. (8) Guide subordinates in their work and support them in their addressing problems in work processes.	(11) Take the responsibility for sorting out consumption states of materials and technological countermeasures, making analysis and reports on them, and managing price reduction and cost saving. (12) Take the responsibility for managing the asset register of the company, and for supervising, promoting, and inspecting asset use status of related organizations. (13) Take the responsibility for giving guidance on development of education and training to equipment maintenance organizations. (14) Take the responsibility for studying and comprehending new achievements of technologies, managing the direction of proceedings of expertise and efforts for development, and studying technology innovation for updating equipment.

Roles, responsibilities, and competence of each job duty in the equipment sections (the inspection and repair centers) of OU

Manager	Deputy Manager (Safety)	Deputy Manager (Operation)	Section Engineer	Leader	Worker
(1) Take the responsibility for managing the center under his or her control; issuing instructions and guidance on formulation and implementation of each project; and inspecting, observing, promoting, and managing the implementation. (2) Take the responsibility for issuing instructions and guidance, based on related rules of the company, on formulation and implementation of detailed implementation plans, duty standards, and work procedures of the center under his or her control. (3) Take the responsibility for building and completing the safety management system of the center and achieving	(1) Support the manager to manage the center in a comprehensive manner and carry out work in his or her charge. (2) Formulate and report construction execution plans and maintenance plans of the center, obtain approval for them, and then take responsibility for issuing instructions and guidance on implementation of them. (3) Hold periodically a meeting on safety of the center, and take responsibility for the safety of the center in a comprehensive manner. (4) Issue instructions and guidance on safety inspection; secure facilities, equipment on which safety should be secured, and materials for	(1) Manage risk falling into his/her management scope according to a risk level, and make recording, analysis, inspection/observation, and adjustment. Take responsibility for reporting to higher-ranking persons in conformity to rules, proposing effective measures, and implementing them. (2) Support the manager and carry out business in his/her charge. Based on a fiscal-year maintenance plan of the maintenance center, issue instructions and guidance on formulation of a maintenance budget, and implement it following maintenance indexes the company has specified. (3) Take the responsibility for formulating methods of securing equipment maintenance and operation under special circumstances and on public holidays and festival days, and for	(1) Subject to the corporate rules, take responsibility for formulating manuals and the like for maintenance of facilities and equipment each engineer is in charge of within the scope of his/her duty in the center. (2) Take the responsibility for drawing up a maintenance plan for every month and for every quarter in response to maintenance requests from the company and also for inspecting and observing implementation of each plan. (3) Take the responsibility for managing status of complying with indexes each engineer is in charge of based on equipment maintenance budget indexes the company has specified, and for compiling statistics on equipment maintenance costs. (4) Take the responsibility for	[Common items] - Issue work instructions to workers. - Take responsibility for all work items specified in the work instruction. - Receive and check results of the work workers have performed without his or her presence. - When a failure occurs, input necessary data into the equipment failure database after repair work. [Inspection (periodical and occasional)] - Make judgment on conditions of equipment at whose inspection he or she was present. - Receive and check results of inspection by workers at which he or she was not present.	[Common items] - Carry out the work ordered by a leader. [Inspection (periodical and occasional)] - Conduct the inspection ordered by a leader. - In the case without leader's presence, make a judgment on equipment conditions. - In the case without leader's presence, go back to the office and make a report to a leader on equipment conditions. [Repair/Revamping] - Carry out repair or revamping work subject to leader's order. - Make a judgment on results of repair or revamping in the case without leader's

conditions specified by yearly safety management indexes. (4) Take the responsibility for issuing instructions and guidance on rescues in sudden accidents, emergency measures, and recovery work, and also for working on site. (5) Take the responsibility for issuing instructions and guidance on formulating a rescue and emergency project of the center, issuing guidance on planning each project for the center, conducting periodical trainings, building an emergency rescue system and continually improving it. (6) Take the responsibility for managing assets and materials in the center under his or her control.	emergency rescue work so that they can be used as normal, issue guidance on and promote safety inspection of the center. (5) Take the responsibility for issuing instructions and guidance on site, responding to emergency accidents and incidents, and taking emergency procedures. (6) Take the responsibility for formulating a project concerning emergency response to sudden accidents of the center, conducting periodical trainings, and building an emergency rescue system of the center and continually improving it. (7) Take the responsibility for issuing instructions and guidance on management of materials and resources of the center. (8) Take the responsibility	issuing instructions and guidance on implementation of them subject to approval of the company. (4) Take the responsibility for properly making business adjustment and negotiations with internal and external organizations. (5) Take the responsibility for issuing instructions and guidance on management and measurement of energy use in the center, control of energy saving, and reduction and control of emissions. (6) Take the responsibility for building a scheme for securing and inspecting/observing maintenance quality. (7) Take the responsibility for issuing instructions and guidance on formulation of budgets for costs of equipment operation safety, employee training, etc., and at the same time, rigorously managing budget execution status and making periodical reports. (8) Take the responsibility for managing and using equipment to be operated within a management	formulating a maintenance plan and a construction execution scheme, submitting an application for approval of them, and executing them. (5) Take the responsibility for making analysis and compiling statistics on energy consumption of equipment within a scope each engineer is in charge of, and for taking measures for reduction of emissions and electricity saving. (6) Take the responsibility for managing technical data and documents of the center. (7) Take the responsibility for training employees working in the center on primary and middle-grade skills. (8) Take the responsibility for planning an emergency rescue project and other projects of the center; periodically conducting a training; building an emergency rescue system of the center; and continually improving it.	[Repair/Revamping] - Make a study and a decision on necessary handling. - Make a judgment on results of repair or revamping at whose execution he or she was present. - Receive and check results of repair or revamping workers implemented without his or her presence. [Asset register] - When a change happens in assets, receive and check details workers wrote in the asset register.	presence. - In the case without leader's presence, go back to office and make a report to the leader on equipment conditions after repair or revamping. [Asset register] - When a change happens in assets, write it in the asset register.

	for drawing up and submitting statistical and analysis reports.	scope in a unified manner. (9) Formulate personnel training plans based on the human resources development plan of the company, and issue instructions and guidance on implementation of the plans.			

Method for calculating the number of personnel for the OUs (operation units)

1. Purpose

This document is intended to help understand the way of deploying personnel for operation units and the way of developing a plan related to maintenance works, and encourage the company to promptly approve a personnel plan and personnel allocation.

2. Guidelines for preparing materials

2.1. Prerequisites for preparing materials

- Laws and regulation stipulate that an employer must not allow its employees to work for over 8 hours per day and 40 hours per week.
- The numbers of pieces of equipment related to signaling, power supply and electric machinery (M&E) are assumed (when the materials are prepared). This is because there is not much information on the equipment for the Line 2A when the materials are prepared.
- Organizational structures of the electric divisions at the headquarters and the operation units
- Periodical/monthly maintenance plan
- Abilities of workers (including the leader) shall be secured (after being educated, workers can engage in maintenance works)

2.2. Methodology for preparing a shift table

- One week consists of seven days, which are equivalent to 168 hours.

- To ensure continuous execution of maintenance works (i.e., workers are always deployed for 24 hours), it is necessary to divide a team of maintenance personnel into three shifts (8 hours on duty and 1 hour of rest for each shift).
- It is necessary to ensure that each worker rests for 24 hours after completing his/her shift.
- The maximum on-duty hours of each worker are 40 hours per week.

➔ To satisfy the above conditions, the following number of maintenance teams will be required.

168 (hours per week) ÷ 40 (maximum on-duty hours of each worker)

= 4.2 (rounded up to 5)

Therefore, five worker teams need to be deployed in order to execute the maintenance works.

Since the equipment maintenance works vary, the headcounts of teams may also vary.

Based on the above assumption, a shift table can be prepared as follows.

<u>Shift table</u>

	On-duty hours: 9 hours Including 1-hour rest	Team A	Team B	Team C	Team D	Team E
Day 1	7:00 - 16:00	○				
	15:00 - 24:00		○			
	23:00 - 8:00			○		
Day 2	7:00 - 16:00				○	
	15:00 - 24:00					○
	23:00 - 8:00	○				
Day 3	7:00 - 16:00		○			
	15:00 - 24:00			○		
	23:00 - 8:00				○	
Day 4	7:00 - 16:00					○
	15:00 - 24:00	○				
	23:00 - 8:00		○			
Day 5	7:00 - 16:00			○		
	15:00 - 24:00				○	

	23:00 - 8:00					○
Day 6	7:00 - 16:00	○				
	15:00 - 24:00		○			
	23:00 - 8:00			○		
Day 7	7:00 - 16:00				○	
	15:00 - 24:00					○
	23:00 - 8:00	○				
Total	Working hours in 7 days	40 hours	32 hours	32 hours	32 hours	32 hours

In the second week, team B will be the first to execute the operation. The shift sequence is as shown in the above shift table.

2.3. Methodology for calculating the number(s) of administrative personnel (*Manager, Deputy Manager and Engineer* ***)***

- Positions other than Manager, such as Deputy Manager and Engineer, can perform the shift works.
- To deploy an administrator for each shift team under the 3-shift structure, a sufficient number of administrators will be required.
- To ensure simplicity and convenience of administration without substantially increasing the number of administrators, the Deputy Manager will perform the Engineer's duties. Therefore, to ensure the administration of the 3-shift work structure, at least the number of Deputy Managers will be increased.
- Deputy Manager and Engineer can administer or instruct personnel engaging in the maintenance works by directly going to the work site.
- An administrator for instructing maintenance personnel at time of roll call will be required.
- One Engineer will be required for each equipment unit (communication, signals, AFC, power, M&E). If the Engineer is absent, the Deputy Manager can act for the Engineer.

➔ At each maintenance center, 5 to 6 Deputy Managers (administrators) (for 5 teams + one reserve) will be required.

2.4. Methodology for calculating the number of maintenance personnel (workers)

- Clarify a specific quantity of equipment.
- The headcount of each team is an average headcount. Since each line has different equipment, it is necessary to clarify the equipment specifications, equipment inspection criterion table, equipment maintenance manual, worker ability (standard and actual ability), etc. in order to classify the equipment and appropriately determine the number of maintenance personnel.
- There is some equipment for which an inspection cycle and inspection items have not been defined under the laws and regulation of Vietnam. There is also equipment for which specifications have not been specified. Therefore, under these circumstances it is necessary to calculate the headcount based on shift work of the work team. As a means of the calculation, prepare a roadmap for the maintenance works. Based on this roadmap, the number of personnel for the electric divisions at the OUs can be calculated.
- Take into account elements such as days-off, sickness, etc. of maintenance personnel.

Calculation of the number of personnel for each maintenance item at the electric division

(1) Items of communication equipment maintenance

The communication equipment shall be maintained (train radio, telephones, exchange system, broadcasting system, automatic passenger guiding system, communication network, communication line, television system for monitoring, electric clock, station disaster control monitoring system, etc.)

5 teams × (3 to 4 workers/team) = 15 to 20 workers

➔ If the assumed equipment were actually used, 15 to 20 workers would be enough. However, the headcount for each team will substantially vary depending on these pieces of equipment, difference in equipment, inspection cycle, part replacement cycle, and type/quantity of replacement parts (3 to 4 workers/team here).

(2) Items of signal equipment maintenance

The signaling systems and traffic control system shall be maintained.

5 teams × (3 to 4 workers/team) = 15 to 20 workers

➔ If the assumed equipment were actually used, 15 to 20 workers would be enough. However, the headcount for each team will substantially vary depending on these pieces of equipment, difference in equipment, inspection cycle, part replacement cycle, and type/quantity of replacement parts (3 to 4 workers/team here).

(3) Items of AFC equipment maintenance

Equipment such as ticket gates and ticket machines shall be maintained.

5 teams × (3 to 4 workers/team) = 15 to 20 workers

➔ If the assumed equipment were actually used, 15 to 20 workers would be enough. However, the headcount for each team will substantially vary depending on these pieces of equipment, difference in equipment, inspection cycle, part replacement cycle, and type/quantity of replacement parts (3 to 4 workers/team here).

(4) Items of M&E equipment maintenance

The M&E equipment shall be equipment such as escalators (48 escalators), lightings, ventilation, air conditioning, and pumps.

Five teams will maintain the escalators.

5 teams × (3 to 4 workers/team) = 15 to 20 workers

Therefore, if three teams were operative, there would be 13 opportunities for maintenance per week, or 52 opportunities for four weeks. If it is assumed that there are 48 escalators, one or two teams will be staffed with only one or two workers. These teams will perform only emergency response in case of failure.

In such situations, five other teams will maintain the equipment.

5 teams × (3 to 4 workers/team) = 15 to 20 workers

➔ In total, 30 to 40 workers will be required for maintaining the M&E equipment. If the assumed equipment were actually used, 30 to 40 workers would be enough. However, the headcount for each team will substantially vary depending on these pieces of equipment, difference in equipment, inspection cycle, part replacement cycle, and type/quantity of replacement parts (3 to 4 workers/team here).

(5) Items of power supply equipment maintenance

The power management system, substation (receiving station) (× 7), electric room (× 12) + depot, third rail (35 km), and transmission/distribution lines shall be maintained.

5 teams × (3 to 4 workers/team) = 15 to 20 workers

➔ If the assumed equipment were actually used, 15 to 20 workers would be enough. However, the headcount for each team will substantially vary depending on these pieces of equipment, difference in equipment, inspection cycle, part replacement cycle, and type/quantity of replacement parts (3 to 4 workers/team here).

(6) Items of elevator maintenance

The number of elevators shall be 50.

5 teams × (2 to 3 workers/team) = 10 to 15 workers

As with the escalators, if three teams were operative, there would be 13 opportunities for maintenance per week, or 52 opportunities for four weeks. The five teams will include one or two teams each staffed with one or two workers, and these teams will perform only emergency response in case of failure.

➔ If the assumed equipment were actually used, 10 to 15 workers would be enough. However, the headcount for each team will substantially vary depending on these pieces of equipment, difference in equipment, inspection cycle, part replacement cycle, and type/quantity of replacement parts (2 to 3 workers/team here). However, since elevator maintenance personnel will not be educated for the Line 2A project, the elevator maintenance shall be subcontracted or maintenance personnel shall be employed (employed personnel must satisfy the legal/regulatory requirements).

(A detailed personnel headcount calculation table will be attached to this document)

Table of calculation of worker (including Leader) personnel at OU [basic No. of personnel]

◇Basic number	Personnel per team		Working teams per day		No. of days		Total No. of personnel in 30 days	
	3.5	∗	3	∗	30	=	315	[workers]
	2.5	∗	3	∗	30	=	225	[workers]

◇Monthly plan	Personnel per team		No. of teams		No. of on-duty days per team		Total No. of personnel in 30 days	
Communication	3.5	∗	5	∗	18	=	315	[workers]
Signals	3.5	∗	5	∗	18	=	315	[workers]
AFC	3.5	∗	5	∗	18	=	315	[workers]
Power	3.5	∗	5	∗	18	=	315	[workers]
M&E (other than ES)	3.5	∗	5	∗	18	=	315	[workers]
M&E (ES)	3.5	∗	5	∗	18	=	315	[workers]
EV	2.5	∗	5	∗	18	=	225	[workers]

◆No. of personnel	Personnel per team		No. of teams			Rounded up	Reserve personnel	Personnel	
Communication	3.5	∗	5	=	17.5	18	1	19	[workers]
Signals	3.5	∗	5	=	17.5	18	1	19	[workers]
AFC	3.5	∗	5	=	17.5	18	1	19	[workers]
Power	3.5	∗	5	=	17.5	18	1	19	[workers]
M&E (other than ES)	3.5	∗	5	=	17.5	18	1	19	[workers]
M&E (ES)	3.5	∗	5	=	17.5	18	1	19	[workers]
EV	2.5	∗	5	=	12.5	13	1	14	[workers]

	Communication	Signals	AFC	Power	M&E (other than ES)	M&E (ES)	EV
Basic number per team	3.5	3.5	3.5	3.5	3.5	3.5	2.5
Total No. of basic teams in 30 days	90	90	90	90	90	90	90
Total No. of actual teams in 30 days	90	90	90	90	90	90	90
Total No. of personnel in 30 days	315	315	315	315	315	315	225

Days	On-duty hours	Team							
1	7～16	A	1	1	1	1	1	1	1
1	15～24	B	1	1	1	1	1	1	1
1	23～8	C	1	1	1	1	1	1	1
2	7～16	D	1	1	1	1	1	1	1
2	15～24	E	1	1	1	1	1	1	1
2	23～8	A	1	1	1	1	1	1	1
3	7～16	B	1	1	1	1	1	1	1
3	15～24	C	1	1	1	1	1	1	1
3	23～8	D	1	1	1	1	1	1	1
4	7～16	E	1	1	1	1	1	1	1
4	15～24	A	1	1	1	1	1	1	1
4	23～8	B	1	1	1	1	1	1	1
5	7～16	C	1	1	1	1	1	1	1
5	15～24	D	1	1	1	1	1	1	1
5	23～8	E	1	1	1	1	1	1	1
6	7～16	A	1	1	1	1	1	1	1
6	15～24	B	1	1	1	1	1	1	1
6	23～8	C	1	1	1	1	1	1	1
7	7～16	D	1	1	1	1	1	1	1
7	15～24	E	1	1	1	1	1	1	1
7	23～8	A	1	1	1	1	1	1	1
8	7～16	B	1	1	1	1	1	1	1
8	15～24	C	1	1	1	1	1	1	1
8	23～8	D	1	1	1	1	1	1	1
9	7～16	E	1	1	1	1	1	1	1
9	15～24	A	1	1	1	1	1	1	1
9	23～8	B	1	1	1	1	1	1	1
10	7～16	C	1	1	1	1	1	1	1
10	15～24	D	1	1	1	1	1	1	1
10	23～8	E	1	1	1	1	1	1	1
11	7～16	A	1	1	1	1	1	1	1
11	15～24	B	1	1	1	1	1	1	1
11	23～8	C	1	1	1	1	1	1	1
12	7～16	D	1	1	1	1	1	1	1
12	15～24	E	1	1	1	1	1	1	1
12	23～8	A	1	1	1	1	1	1	1
13	7～16	B	1	1	1	1	1	1	1
13	15～24	C	1	1	1	1	1	1	1
13	23～8	D	1	1	1	1	1	1	1
14	7～16	E	1	1	1	1	1	1	1
14	15～24	A	1	1	1	1	1	1	1
14	23～8	B	1	1	1	1	1	1	1
15	7～16	C	1	1	1	1	1	1	1
15	15～24	D	1	1	1	1	1	1	1
15	23～8	E	1	1	1	1	1	1	1
16	7～16	A	1	1	1	1	1	1	1
16	15～24	B	1	1	1	1	1	1	1
16	23～8	C	1	1	1	1	1	1	1
17	7～16	D	1	1	1	1	1	1	1
17	15～24	E	1	1	1	1	1	1	1
17	23～8	A	1	1	1	1	1	1	1
18	7～16	B	1	1	1	1	1	1	1
18	15～24	C	1	1	1	1	1	1	1
18	23～8	D	1	1	1	1	1	1	1
19	7～16	E	1	1	1	1	1	1	1
19	15～24	A	1	1	1	1	1	1	1
19	23～8	B	1	1	1	1	1	1	1
20	7～16	C	1	1	1	1	1	1	1
20	15～24	D	1	1	1	1	1	1	1
20	23～8	E	1	1	1	1	1	1	1
21	7～16	A	1	1	1	1	1	1	1
21	15～24	B	1	1	1	1	1	1	1
21	23～8	C	1	1	1	1	1	1	1
22	7～16	D	1	1	1	1	1	1	1
22	15～24	E	1	1	1	1	1	1	1
22	23～8	A	1	1	1	1	1	1	1
23	7～16	B	1	1	1	1	1	1	1
23	15～24	C	1	1	1	1	1	1	1
23	23～8	D	1	1	1	1	1	1	1
24	7～16	E	1	1	1	1	1	1	1
24	15～24	A	1	1	1	1	1	1	1
24	23～8	B	1	1	1	1	1	1	1
25	7～16	C	1	1	1	1	1	1	1
25	15～24	D	1	1	1	1	1	1	1
25	23～8	E	1	1	1	1	1	1	1
26	7～16	A	1	1	1	1	1	1	1
26	15～24	B	1	1	1	1	1	1	1
26	23～8	C	1	1	1	1	1	1	1
27	7～16	D	1	1	1	1	1	1	1
27	15～24	E	1	1	1	1	1	1	1
27	23～8	A	1	1	1	1	1	1	1
28	7～16	B	1	1	1	1	1	1	1
28	15～24	C	1	1	1	1	1	1	1
28	23～8	D	1	1	1	1	1	1	1
29	7～16	E	1	1	1	1	1	1	1
29	15～24	A	1	1	1	1	1	1	1
29	23～8	B	1	1	1	1	1	1	1
30	7～16	C	1	1	1	1	1	1	1
30	15～24	D	1	1	1	1	1	1	1
30	23～8	E	1	1	1	1	1	1	1
31	7～16								
31	15～24								
31	23～8								

Table of calculation of worker (including Leader) personnel at OU [example 1]

◇Basic number	Personnel per team		Working teams per day		No. of days		Total No. of personnel in 30 days	
	3.5	∗	3	∗	30	＝	315	[workers]
	2.5	∗	3	∗	30	＝	225	[workers]

◇Monthly plan	Personnel per team		No. of teams		No. of on-duty days per team		Total No. of personnel in 30 days	
Communication	3.4	∗	5	∗	18	＝	306	[workers]
Signals	3.4	∗	5	∗	18	＝	306	[workers]
AFC	3.4	∗	5	∗	18	＝	306	[workers]
Power	3.4	∗	5	∗	18	＝	306	[workers]
M&E (other than ES)	3.4	∗	5	∗	18	＝	306	[workers]
M&E (ES)	3.3	∗	5	∗	18	＝	297	[workers]
EV	2.4	∗	5	∗	18	＝	216	[workers]

◆No. of personnel	Personnel per team		No. of teams			Rounded up	Reserve personnel	Personnel	
Communication	3.4	∗	5	＝	17	17	1	18	[workers]
Signals	3.4	∗	5	＝	17	17	1	18	[workers]
AFC	3.4	∗	5	＝	17	17	1	18	[workers]
Power	3.4	∗	5	＝	17	17	1	18	[workers]
M&E (other than ES)	3.4	∗	5	＝	17	17	1	18	[workers]
M&E (ES)	3.3	∗	5	＝	16.5	17	1	18	[workers]
EV	2.4	∗	5	＝	12	12	1	13	[workers]

	Communication	Signals	AFC	Power	M&E (other than ES)	M&E (ES)	EV
Basic number per team	3.5	3.5	3.5	3.5	3.5	3.5	2.5
Total No. of basic teams in 30 days	90	90	90	90	90	90	90
Total No. of actual teams in 30 days	87.2	87.2	87.2	87.2	87.2	82.8	86.4
Total No. of personnel in 30 days	305.2	305.2	305.2	305.2	305.2	289.8	216

Days	On-duty hours	Team							
1	7～16	A	1	1	1	1	1	1	1
1	15～24	B	1	1	1	1	1	1	1
1	23～8	C	1	1	1	1	1	1	1
2	7～16	D	1	1	1	1	1	1	1
2	15～24	E	1	1	1	1	1	0.6	0.8
2	23～8	A	1	1	1	1	1	1	1
3	7～16	B	1	1	1	1	1	1	1
3	15～24	C	1	1	1	1	1	1	1
3	23～8	D	1	1	1	1	1	1	1
4	7～16	E	1	1	1	1	1	0.6	0.8
4	15～24	A	1	1	1	1	1	1	1
4	23～8	B	1	1	1	1	1	1	1
5	7～16	C	1	1	1	1	1	1	1
5	15～24	D	1	1	1	1	1	1	1
5	23～8	E	1	1	1	1	1	0.6	0.8
6	7～16	A	1	1	1	1	1	1	1
6	15～24	B	1	1	1	1	1	1	1
6	23～8	C	1	1	1	1	1	1	1
7	7～16	D	1	1	1	1	1	1	1
7	15～24	E	1	1	1	1	1	0.6	0.8
7	23～8	A	1	1	1	1	1	1	1
8	7～16	B	1	1	1	1	1	1	1
8	15～24	C	1	1	1	1	1	1	1
8	23～8	D	1	1	1	1	1	1	1
9	7～16	E	1	1	1	1	1	0.6	0.8
9	15～24	A	1	1	1	1	1	1	1
9	23～8	B	1	1	1	1	1	1	1
10	7～16	C	1	1	1	1	1	1	1
10	15～24	D	1	1	1	1	1	1	1
10	23～8	E	1	1	1	1	1	0.6	0.8
11	7～16	A	1	1	1	1	1	1	1
11	15～24	B	1	1	1	1	1	1	1
11	23～8	C	1	1	1	1	1	1	1
12	7～16	D	1	1	1	1	1	1	1
12	15～24	E	1	1	1	1	1	0.6	0.8
12	23～8	A	1	1	1	1	1	1	1
13	7～16	B	1	1	1	1	1	1	1
13	15～24	C	1	1	1	1	1	1	1
13	23～8	D	1	1	1	1	1	1	1
14	7～16	E	1	1	1	1	1	0.6	0.8
14	15～24	A	1	1	1	1	1	1	1
14	23～8	B	1	1	1	1	1	1	1
15	7～16	C	1	1	1	1	1	1	1
15	15～24	D	1	1	1	1	1	1	1
15	23～8	E	1	1	1	1	1	0.6	0.8
16	7～16	A	1	1	1	1	1	1	1
16	15～24	B	1	1	1	1	1	1	1
16	23～8	C	1	1	1	1	1	1	1
17	7～16	D	1	1	1	1	1	1	1
17	15～24	E	1	1	1	1	1	0.6	0.8
17	23～8	A	1	1	1	1	1	1	1
18	7～16	B	1	1	1	1	1	1	1
18	15～24	C	1	1	1	1	1	1	1
18	23～8	D	1	1	1	1	1	1	1
19	7～16	E	1	1	1	1	1	0.6	0.8
19	15～24	A	1	1	1	1	1	1	1
19	23～8	B	1	1	1	1	1	1	1
20	7～16	C	1	1	1	1	1	1	1
20	15～24	D	1	1	1	1	1	1	1
20	23～8	E	1	1	1	1	1	0.6	0.8
21	7～16	A	1	1	1	1	1	1	1
21	15～24	B	1	1	1	1	1	1	1
21	23～8	C	1	1	1	1	1	1	1
22	7～16	D	1	1	1	1	1	1	1
22	15～24	E	1	1	1	1	1	0.6	0.8
22	23～8	A	1	1	1	1	1	1	1
23	7～16	B	1	1	1	1	1	1	1
23	15～24	C	1	1	1	1	1	1	1
23	23～8	D	1	1	1	1	1	1	1
24	7～16	E	1	1	1	1	1	0.6	0.8
24	15～24	A	0.6	0.6	0.6	0.6	0.6	1	1
24	23～8	B	1	1	1	1	1	1	1
25	7～16	C	1	1	1	1	1	1	1
25	15～24	D	0.6	0.6	0.6	0.6	0.6	1	1
25	23～8	E	1	1	1	1	1	0.6	0.8
26	7～16	A	1	1	1	1	1	1	1
26	15～24	B	0.6	0.6	0.6	0.6	0.6	1	1
26	23～8	C	1	1	1	1	1	1	1
27	7～16	D	1	1	1	1	1	1	1
27	15～24	E	0.6	0.6	0.6	0.6	0.6	0.6	0.8
27	23～8	A	1	1	1	1	1	1	1
28	7～16	B	1	1	1	1	1	1	1
28	15～24	C	0.6	0.6	0.6	0.6	0.6	1	1
28	23～8	D	1	1	1	1	1	1	1
29	7～16	E	1	1	1	1	1	0.6	0.8
29	15～24	A	0.6	0.6	0.6	0.6	0.6	1	1
29	23～8	B	1	1	1	1	1	1	1
30	7～16	C	1	1	1	1	1	1	1
30	15～24	D	0.6	0.6	0.6	0.6	0.6	1	1
30	23～8	E	1	1	1	1	1	0.6	0.8
31	7～16								
31	15～24								
31	23～8								

Table of calculation of worker (including Leader) personnel at OU [example 2]

◇Basic number	Personnel per team		Working teams per day		No. of days		Total No. of personnel in 30 days	
	3.5	∗	3	∗	30	=	315	[workers]
	2.5	∗	3	∗	30	=	225	[workers]

◇Monthly plan	Personnel per team		No. of teams		No. of on-duty days per team		Total No. of personnel in 30 days	
Communication	3.2	∗	5	∗	18	=	288	[workers]
Signals	3.2	∗	5	∗	18	=	288	[workers]
AFC	3.2	∗	5	∗	18	=	288	[workers]
Power	3.2	∗	5	∗	18	=	288	[workers]
M&E (other than ES)	3.2	∗	5	∗	18	=	288	[workers]
M&E (ES)	3.2	∗	5	∗	18	=	288	[workers]
EV	2.4	∗	5	∗	18	=	216	[workers]

◆No. of personnel	Personnel per team		No. of teams			Rounded up	Reserve personnel	Personnel	
Communication	3.2	∗	5	=	16	16	1	17	[workers]
Signals	3.2	∗	5	=	16	16	1	17	[workers]
AFC	3.2	∗	5	=	16	16	1	17	[workers]
Power	3.2	∗	5	=	16	16	1	17	[workers]
M&E (other than ES)	3.2	∗	5	=	16	16	1	17	[workers]
M&E (ES)	3.2	∗	5	=	16	16	1	17	[workers]
EV	2.4	∗	5	=	12	12	1	13	[workers]

	Communication	Signals	AFC	Power	M&E (other than ES)	M&E (ES)	EV
Basic number per team	3.5	3.5	3.5	3.5	3.5	3.5	2.5
Total No. of basic teams in 30 days	90	90	90	90	90	90	90
Total No. of actual teams in 30 days	78	78	78	78	78	82.8	86.4
Total No. of personnel in 30 days	273	273	273	273	273	289.8	216

Days	On-duty hours	Team						
1	7～16	A	1	1	1	1	1	1	1
1	15～24	B	0.6	0.6	0.6	0.6	0.6	1	1
1	23～8	C	1	1	1	1	1	1	1
2	7～16	D	1	1	1	1	1	1	1
2	15～24	E	0.6	0.6	0.6	0.6	0.6	0.6	0.8
2	23～8	A	1	1	1	1	1	1	1
3	7～16	B	1	1	1	1	1	1	1
3	15～24	C	0.6	0.6	0.6	0.6	0.6	1	1
3	23～8	D	1	1	1	1	1	1	1
4	7～16	E	1	1	1	1	1	0.6	0.8
4	15～24	A	0.6	0.6	0.6	0.6	0.6	1	1
4	23～8	B	1	1	1	1	1	1	1
5	7～16	C	1	1	1	1	1	1	1
5	15～24	D	0.6	0.6	0.6	0.6	0.6	1	1
5	23～8	E	1	1	1	1	1	0.6	0.8
6	7～16	A	1	1	1	1	1	1	1
6	15～24	B	0.6	0.6	0.6	0.6	0.6	1	1
6	23～8	C	1	1	1	1	1	1	1
7	7～16	D	1	1	1	1	1	1	1
7	15～24	E	0.6	0.6	0.6	0.6	0.6	0.6	0.8
7	23～8	A	1	1	1	1	1	1	1
8	7～16	B	1	1	1	1	1	1	1
8	15～24	C	0.6	0.6	0.6	0.6	0.6	1	1
8	23～8	D	1	1	1	1	1	1	1
9	7～16	E	1	1	1	1	1	0.6	0.8
9	15～24	A	0.6	0.6	0.6	0.6	0.6	1	1
9	23～8	B	1	1	1	1	1	1	1
10	7～16	C	1	1	1	1	1	1	1
10	15～24	D	0.6	0.6	0.6	0.6	0.6	1	1
10	23～8	E	1	1	1	1	1	0.6	0.8
11	7～16	A	1	1	1	1	1	1	1
11	15～24	B	0.6	0.6	0.6	0.6	0.6	1	1
11	23～8	C	1	1	1	1	1	1	1
12	7～16	D	1	1	1	1	1	1	1
12	15～24	E	0.6	0.6	0.6	0.6	0.6	0.6	0.8
12	23～8	A	1	1	1	1	1	1	1
13	7～16	B	1	1	1	1	1	1	1
13	15～24	C	0.6	0.6	0.6	0.6	0.6	1	1
13	23～8	D	1	1	1	1	1	1	1
14	7～16	E	1	1	1	1	1	0.6	0.8
14	15～24	A	0.6	0.6	0.6	0.6	0.6	1	1
14	23～8	B	1	1	1	1	1	1	1
15	7～16	C	1	1	1	1	1	1	1
15	15～24	D	0.6	0.6	0.6	0.6	0.6	1	1
15	23～8	E	1	1	1	1	1	0.6	0.8
16	7～16	A	1	1	1	1	1	1	1
16	15～24	B	0.6	0.6	0.6	0.6	0.6	1	1
16	23～8	C	1	1	1	1	1	1	1
17	7～16	D	1	1	1	1	1	1	1
17	15～24	E	0.6	0.6	0.6	0.6	0.6	0.6	0.8
17	23～8	A	1	1	1	1	1	1	1
18	7～16	B	1	1	1	1	1	1	1
18	15～24	C	0.6	0.6	0.6	0.6	0.6	1	1
18	23～8	D	1	1	1	1	1	1	1
19	7～16	E	1	1	1	1	1	0.6	0.8
19	15～24	A	0.6	0.6	0.6	0.6	0.6	1	1
19	23～8	B	1	1	1	1	1	1	1
20	7～16	C	1	1	1	1	1	1	1
20	15～24	D	0.6	0.6	0.6	0.6	0.6	1	1
20	23～8	E	1	1	1	1	1	0.6	0.8
21	7～16	A	1	1	1	1	1	1	1
21	15～24	B	0.6	0.6	0.6	0.6	0.6	1	1
21	23～8	C	1	1	1	1	1	1	1
22	7～16	D	1	1	1	1	1	1	1
22	15～24	E	0.6	0.6	0.6	0.6	0.6	0.6	0.8
22	23～8	A	1	1	1	1	1	1	1
23	7～16	B	1	1	1	1	1	1	1
23	15～24	C	0.6	0.6	0.6	0.6	0.6	1	1
23	23～8	D	1	1	1	1	1	1	1
24	7～16	E	1	1	1	1	1	0.6	0.8
24	15～24	A	0.6	0.6	0.6	0.6	0.6	1	1
24	23～8	B	1	1	1	1	1	1	1
25	7～16	C	1	1	1	1	1	1	1
25	15～24	D	0.6	0.6	0.6	0.6	0.6	1	1
25	23～8	E	1	1	1	1	1	0.6	0.8
26	7～16	A	1	1	1	1	1	1	1
26	15～24	B	0.6	0.6	0.6	0.6	0.6	1	1
26	23～8	C	1	1	1	1	1	1	1
27	7～16	D	1	1	1	1	1	1	1
27	15～24	E	0.6	0.6	0.6	0.6	0.6	0.6	0.8
27	23～8	A	1	1	1	1	1	1	1
28	7～16	B	1	1	1	1	1	1	1
28	15～24	C	0.6	0.6	0.6	0.6	0.6	1	1
28	23～8	D	1	1	1	1	1	1	1
29	7～16	E	1	1	1	1	1	0.6	0.8
29	15～24	A	0.6	0.6	0.6	0.6	0.6	1	1
29	23～8	B	1	1	1	1	1	1	1
30	7～16	C	1	1	1	1	1	1	1
30	15～24	D	0.6	0.6	0.6	0.6	0.6	1	1
30	23～8	E	1	1	1	1	1	0.6	0.8
31	7～16								
31	15～24								
31	23～8								

Table of calculation of worker (including Leader) personnel at OU [example 3]

○ 3.5 is temporarily set because the actual number will be 3 to 4.

○ 2.5 is temporarily set because the actual number will be 2 to 3.

◇Basic number	Personnel per team		Working teams per day		No. of days		Total No. of personnel in 30 days	
	3.5	∗	3	∗	30	＝	315	[workers]
	2.5	∗	3	∗	30	＝	225	[workers]

III Set the number of personnel per team (3.3 ⇒ 297) that is not below the total number of personnel in 30 days (290.5).

◇Monthly plan	Personnel per team		No. of teams		No. of on-duty days per team		Total No. of personnel in 30 days	
Communication	3.3	∗	5	∗	18	＝	297	[workers]
Signals	3.3	∗	5	∗	18	＝	297	[workers]
AFC	3.3	∗	5	∗	18	＝	297	[workers]
Power	3.3	∗	5	∗	18	＝	297	[workers]
M&E (other than ES)	3.3	∗	5	∗	18	＝	297	[workers]
M&E (ES)	3.3	∗	5	∗	18	＝	297	[workers]
EV	2.4	∗	5	∗	18	＝	216	[workers]

III Set the number of personnel per team (2.4 ⇒216) that is not below the total number of personnel in 30 days (216).

○ Reserve personnel shall correspond to injury/illness and days off of employees

◆No. of personnel	Personnel per team		No. of teams			Rounded up	Reserve personnel	Personnel	
Communication	3.3	∗	5	＝	16.5	17	1	18	[workers]
Signals	3.3	∗	5	＝	16.5	17	1	18	[workers]
AFC	3.3	∗	5	＝	16.5	17	1	18	[workers]
Power	3.3	∗	5	＝	16.5	17	1	18	[workers]
M&E (other than ES)	3.3	∗	5	＝	16.5	17	1	18	[workers]
M&E (ES)	3.3	∗	5	＝	16.5	17	1	18	[workers]
EV	2.4	∗	5	＝	12	12	1	13	[workers]

IV No. of personnel is calculated (18).

IV No. of personnel is calculated (13).

II Total No. of personnel in 30 days (290.5)

	Communication	Signals	AFC	Power	M&E (other than ES)	M&E (ES)	EV
Basic number per team	3.5	3.5	3.5	3.5	3.5	3.5	2.5
Total No. of basic teams in 30 days	90	90	90	90	90	90	90
Total No. of actual teams in 30 days	83	83	83	83	83	82.8	86.4
Total No. of personnel in 30 days	290.5	290.5	290.5	290.5	290.5	289.8	216

II Total No. of personnel in 30 days (216)

I Set the number of on-duty personnel.
1＝3.5
0.6≒2
1.5≒5

I Set the number of on-duty personnel.
1＝2.5
0.8＝2

Days	On-duty hours	Team							
1	7～16	A	1	1	1	1	1	1	1
1	15～24	B	0.6	0.6	0.6	0.6	0.6	1	1
1	23～8	C	1.5	1.5	1.5	1.5	1.5	1	1
2	7～16	D	1	1	1	1	1	1	1
2	15～24	E	0.6	0.6	0.6	0.6	0.6	0.6	0.8
2	23～8	A	1.5	1.5	1.5	1.5	1.5	1	1
3	7～16	B	1	1	1	1	1	1	1
3	15～24	C	0.6	0.6	0.6	0.6	0.6	1	1
3	23～8	D	1.5	1.5	1.5	1.5	1.5	1	1
4	7～16	E	1	1	1	1	1	0.6	0.8
4	15～24	A	0.6	0.6	0.6	0.6	0.6	1	1
4	23～8	B	1.5	1.5	1.5	1.5	1.5	1	1
5	7～16	C	1	1	1	1	1	1	1
5	15～24	D	0.6	0.6	0.6	0.6	0.6	1	1
5	23～8	E	1.5	1.5	1.5	1.5	1.5	0.6	0.8
6	7～16	A	1	1	1	1	1	1	1
6	15～24	B	0.6	0.6	0.6	0.6	0.6	1	1
6	23～8	C	1.5	1.5	1.5	1.5	1.5	1	1
7	7～16	D	1	1	1	1	1	1	1
7	15～24	E	0.6	0.6	0.6	0.6	0.6	0.6	0.8
7	23～8	A	1.5	1.5	1.5	1.5	1.5	1	1
8	7～16	B	1	1	1	1	1	1	1
8	15～24	C	0.6	0.6	0.6	0.6	0.6	1	1
8	23～8	D	1.5	1.5	1.5	1.5	1.5	1	1
9	7～16	E	1	1	1	1	1	0.6	0.8
9	15～24	A	0.6	0.6	0.6	0.6	0.6	1	1
9	23～8	B	1.5	1.5	1.5	1.5	1.5	1	1
10	7～16	C	1	1	1	1	1	1	1
10	15～24	D	0.6	0.6	0.6	0.6	0.6	1	1
10	23～8	E	1.5	1.5	1.5	1.5	1.5	0.6	0.8
11	7～16	A	1	1	1	1	1	1	1
11	15～24	B	0.6	0.6	0.6	0.6	0.6	1	1
11	23～8	C	1	1	1	1	1	1	1
12	7～16	D	1	1	1	1	1	1	1
12	15～24	E	0.6	0.6	0.6	0.6	0.6	0.6	0.8
12	23～8	A	1	1	1	1	1	1	1
13	7～16	B	1	1	1	1	1	1	1
13	15～24	C	0.6	0.6	0.6	0.6	0.6	1	1
13	23～8	D	1	1	1	1	1	1	1
14	7～16	E	1	1	1	1	1	0.6	0.8
14	15～24	A	0.6	0.6	0.6	0.6	0.6	1	1
14	23～8	B	1	1	1	1	1	1	1
15	7～16	C	1	1	1	1	1	1	1
15	15～24	D	0.6	0.6	0.6	0.6	0.6	1	1
15	23～8	E	1	1	1	1	1	0.6	0.8
16	7～16	A	1	1	1	1	1	1	1
16	15～24	B	0.6	0.6	0.6	0.6	0.6	1	1
16	23～8	C	1	1	1	1	1	1	1
17	7～16	D	1	1	1	1	1	1	1
17	15～24	E	0.6	0.6	0.6	0.6	0.6	0.6	0.8
17	23～8	A	1	1	1	1	1	1	1
18	7～16	B	1	1	1	1	1	1	1
18	15～24	C	0.6	0.6	0.6	0.6	0.6	1	1
18	23～8	D	1	1	1	1	1	1	1
19	7～16	E	1	1	1	1	1	0.6	0.8
19	15～24	A	0.6	0.6	0.6	0.6	0.6	1	1
19	23～8	B	1	1	1	1	1	1	1
20	7～16	C	1	1	1	1	1	1	1
20	15～24	D	0.6	0.6	0.6	0.6	0.6	1	1
20	23～8	E	1	1	1	1	1	0.6	0.8
21	7～16	A	1	1	1	1	1	1	1
21	15～24	B	0.6	0.6	0.6	0.6	0.6	1	1
21	23～8	C	1	1	1	1	1	1	1
22	7～16	D	1	1	1	1	1	1	1
22	15～24	E	0.6	0.6	0.6	0.6	0.6	0.6	0.8
22	23～8	A	1	1	1	1	1	1	1
23	7～16	B	1	1	1	1	1	1	1
23	15～24	C	0.6	0.6	0.6	0.6	0.6	1	1
23	23～8	D	1	1	1	1	1	1	1
24	7～16	E	1	1	1	1	1	0.6	0.8
24	15～24	A	0.6	0.6	0.6	0.6	0.6	1	1
24	23～8	B	1	1	1	1	1	1	1
25	7～16	C	1	1	1	1	1	1	1
25	15～24	D	0.6	0.6	0.6	0.6	0.6	1	1
25	23～8	E	1	1	1	1	1	0.6	0.8
26	7～16	A	1	1	1	1	1	1	1
26	15～24	B	0.6	0.6	0.6	0.6	0.6	1	1
26	23～8	C	1	1	1	1	1	1	1
27	7～16	D	1	1	1	1	1	1	1
27	15～24	E	0.6	0.6	0.6	0.6	0.6	0.6	0.8
27	23～8	A	1	1	1	1	1	1	1
28	7～16	B	1	1	1	1	1	1	1
28	15～24	C	0.6	0.6	0.6	0.6	0.6	1	1
28	23～8	D	1	1	1	1	1	1	1
29	7～16	E	1	1	1	1	1	0.6	0.8
29	15～24	A	0.6	0.6	0.6	0.6	0.6	1	1
29	23～8	B	1	1	1	1	1	1	1
30	7～16	C	1	1	1	1	1	1	1
30	15～24	D	0.6	0.6	0.6	0.6	0.6	1	1
30	23～8	E	1	1	1	1	1	0.6	0.8
31	7～16								
31	15～24								
31	23～8								

Method for calculating the cost for the required maintenance items (for directly conducted maintenance and outsourced maintenance each)

1. Purpose

The method for calculating the cost for the required maintenance item shall be formulated for the purpose of calculating the maintenance cost accurately, leveling the cost for maintenance items, enabling the company to map out an appropriate direction for development, and increasing the company's profit.

In case of the electric division, it is very important to calculate the cost for the required maintenance items. If the maintenance cost at each stage is accurately calculated with this method, the electric division will be able to level the maintenance process operations, and increase the effect of the maintenance operations, and most importantly, a perfect maintenance work implementation plan can be formulated, and the electric division can implement it.

2. Concept of formulating a method for calculating the cost for the required maintenance items

2.1 Generalization

- Knowing the "cost for the required maintenance items" means calculating the initial cost for implementing the maintenance of the items that require maintenance.
- Initial cost calculation

  In addition to complying with laws and regulation, company rules, and bylaws of the electric division, it is necessary to calculate the accurate initial cost based on the actual circumstances.

2.2 Meaning of calculating the initial cost

The initial cost is the cost that is required when the company provides its product, and the selling price of the product can be expressed as a value calculated by adding a profit to the initial cost.

Price = initial cost + profit (1)

However, recently the price is determined by the needs of the market in many cases. Therefore, it can be said that the profit is determined by the initial cost.

Profit＝price - initial cost (2)

In case of HMC, the passenger transport service corresponds to the product and the fare represents the price. The fare is determined while considering factors such as the ease of use of an urban railway, in a way close to (2) above.

To increase the profit, the initial cost must be reduced. The initial cost contains various costs related to corporate activities, and is deeply connected to the quality of company management. To reduce the initial cost, the quality of company management must be improved through operational improvement, etc.

The initial cost of the passenger transport service that Hanoi Metro Company provides consists of costs of services that the company's respective divisions provide. To increase the profit by reducing the initial cost of the passenger transport service, it is necessary for the respective divisions to pursue operational improvement in order to reduce the initial cost.

To achieve this, each division needs to know the initial cost of their operation. If they know the initial cost of their operation, they will be able to implement efforts for operational improvement based on the initial cost as an index, and evaluate the effect.

As described above, calculation of the cost for the required maintenance items at the electric division has an important meaning for the improvement of management quality of Hanoi Metro Company through management quality improvement at the electric division.

2.3 Composition of the initial cost

The initial cost consists of material cost, labor cost and expense. Therefore, to specify the initial cost, it is necessary to start with determining the labor cost, expense and material cost at the electric division.

Initial cost = material cost + labor cost + expense

2.3.1 Material cost

This cost is generated by material used when the electric division conducts maintenance works. The following is an example of material cost classification, and the cost shall be tallied according to such classification. Details of the calculation will be described later.

1) Cost of parts purchased: cost for parts or units of equipment purchased for maintenance
2) Cost of consumable supplies: cost of consumable supplies used for maintenance
3) Cost of consumable tools and equipment: cost of tools or appliances with short useful life (complying with laws/regulations [if any] or company rules) and small value (complying with laws/regulations [if any] or company rules)
4) Fuel cost: cost of fuel such as gas for welding used for maintenance works

2.3.2 Labor cost

This is an expense concerning staff of the electric division, and its major items are as follows.

1) Salary: salary and bonus paid to staff of the electric division
2) Temporary salary: salary paid to temporarily hired people
3) Reserve for retirement allowance: fund accumulated in preparation for the payment of retirement allowance
4) Welfare cost: health insurance and pension premium, etc.

2.3.3 Expense

All costs excluding labor cost and material cost are included here. The following are examples of expenses.

1) Measuring expense: cost with which consumptions such as electricity and water can be measured
2) Expense payable: travel expense and carfare, telephone and communication, repair cost (cost in case of outsourcing)
3) Monthly expense: cost to be paid in monthly installments such as insurance premiums and lease fees
4) Accrued expense: expense not accompanied by monetary payment even if an event occurs

   For example, if a maintenance part becomes rusted while in storage, it will be disposed of and the amount equivalent to the value of the part will be recorded as a depletion cost.

2.4 Method for calculating the initial cost

2.4.1 Material cost

Material cost shall be calculated by metering each material used for maintenance and multiplying the value with the unit price in principle. However, it is difficult to apply this calculation method to all the materials. For example, it is difficult and unrealistic to meter lubricant oil that is dropped on the slider in a few drips.

Therefore, for example, a method of tallying the cost of materials used for a certain period (e.g., three months, one year) by types, and calculating the average cost per maintenance work based on the count of maintenance in which the material is used, is one of the possible approaches.

1) How to calculate the cost of material used in a certain period

   Based on the inventory value of material possessed at the beginning of the term and the inventory value at the end of the term, as well as the purchase amount of material purchased during the term, the cost can be calculated as follows.

Cost of material used in a certain period = inventory value at the end of the term – inventory value at the beginning of the term +amount of purchase made during the term

2) Method for calculating the material cost for each maintenance item (example)

- Calculate the cost of material used in a certain period for each type of material using the above method
- Specify the material used for each maintenance item.
- Tally the count of maintenance conducted during the above certain period based on the maintenance record. Table 1 shows the result of tallying items (1) to (3).
- Based on the above data, for example the material cost (M_1) of maintenance item 1 (Maintenance 1) can be calculated as follows.

$$M_1 = \frac{X}{(a+c)} + \frac{Y}{(a+b)} + \frac{W}{(a+b+c)}$$

Table 1 Tabulation table for calculating the material cost

		Number of maintenance count	Material 1	Material 2	Material 3	Material 4
Cost material used in a certain period			X	Y	Z	W
Material used, number of maintenance	Maintenance 1	a	✓	✓		✓
	Maintenance 2	b		✓	✓	✓
	Maintenance 3	c	✓		✓	✓

3) In the initial period after the Line 2A is opened, there will be no recorded data on the material used, price, maintenance, etc. Therefore, during Line 2A handover, obtain data on the material used for maintenance, unit price of material, major maintenance items, estimated maintenance frequency, etc. and budget an approximate cost in advance. Additionally, after the Line 2A is opened, accumulate data necessary for the calculation so that initial cost calculation

based on the recorded data can be started in the second year.

2.4.2 Labor cost and expense

1) Cost and items of account

The calculation of the labor cost and the expense begins with clarifying the items of costs incurred in operations of the electric division and tallying each cost in accordance with certain rules. The operations of the electric division extend across the life cycle of equipment from its introduction to operation/maintenance and disposal, and the costs related to operations can be classified as indicated in Table 2. However, since the table is provided only as a reference example, it is necessary to check the actual contents of the operations when preparing it.

Table 2 Costs incurred at the electric division

Cost of equipment introduction		Planning/ design cost	Planning cost
			Basic design cost
			Execution design cost
		Work cost	Carry-in, installation, adjustment/test cost
			Field management cost
		Acquisition extra charge	Application procedure cost
			Disaster control/safety/environmental cost
Equipment maintenance cost	Operation cost	Operation cost	Operation personnel cost
			Daily inspection and maintenance cost
		Energy cost	Electric rate
			Gas rate
			Fuel oil rate
		Operation extra charge	Education and training cost
	Maintenance cost	Maintenance work cost	Overall, general, minute, temporary maintenance cost
		Maintenance extra charge	Equipment maintenance technique management, asset management cost
Equipment disposal cost		Removal cost	Removal and dismantling work cost
		Disposal cost	Equipment selling cost
			Disposal cost

	Disposal extra charge	Environmental cost

On the other hand, in Japan accounting is conducted in accordance with the Railway Business Accounting Rules, which are stipulated under a ministerial order of the Ministry of Land, Infrastructure, Transport and Tourism. Account tiles for classifying costs are also specified in the rules.

(*)Railway Business Accounting Rules:
http://law.e-gov.go.jp/htmldata/S62/S62F03901000007.html

Table 3 shows a list of account titles required for the electric division. The auxiliary division cost represents the initial cost at a division supporting the electric division's operations such as personnel affairs and accounting allocated to the electric division. The idea is that since the auxiliary division's operation services are used for maintenance, such cost must be reflected in the initial cost.

There are several methods for allocating the cost incurred at the auxiliary division. The traditional method is prorating the cost according to the number of personnel at the division to which the cost is allocated. Recently, in an increasing number of cases, the cost is allocated with the ABC (Activity Based Costing) approach (*).

Unless there is any legal rule, the allocation may be implemented in accordance with Hanoi Metro's accounting policy.

(*) Examples include methods of allocating the cost according to the activity level, such as prorating the expense incurred at the purchase division with the number of procurement transactions for the respective divisions.

(1) Precautions for tallying the cost by account titles

Table 3 does not have any account title under which to enter the equipment purchase amount. Structures, equipment, software, etc. that are continuously used for a long period are treated as fixed assets, and purchase amounts cannot be recorded in a lump. It must be noted that during the useful life defined by laws/regulations, a constant-rate or constant-value depreciation amount should be recorded as a cost. In Vietnam, rules related to the useful life and depreciation approach according to the type of equipment are also established under the accounting act and the tax system, and corporate bodies in the country must implement the recording of expenses in accordance with the laws/rule.

The judgment of whether such recording should be performed in the form of cost processing for a fixed asset, or ordinary cost processing can be performed, must be based on the applicable laws/rule, and should be made by the account division, which has expertise.

Table 3 Account titles at the electric division

Classification	Account title
Labor cost	Salary
	Allowance
	Bonus
	Retirement allowance
	Legal welfare cost
	Welfare cost
	Temporary employment wage cost
Expense	Fixed asset retirement cost
	Supplies cost
	Clothing cost
	Power cost
	Utilities cost
	Traveling expense and carfare
	Communication and transportation cost
	Meeting cost
	Expense-account
	Rental
	Nonlife insurance premium

	Miscellaneous
	Tangible fixed asset depreciation cost (transportation facility depreciation cost)
	Intangible fixed asset depreciation cost (transportation facility depreciation cost)
	Auxiliary division cost

(2) How to incorporate the labor cost and expense in the initial cost

There are several methods for incorporating the labor cost and expense in the initial cost of maintenance items. The easiest method is calculating the average value by dividing the sum of the labor cost and the expense by the total time of maintenance works that electric division conducted in one year, and then calculating the necessary cost from the necessary maintenance time for each maintenance item. The following shows the calculation method.

S_{total}: sum of the labor cost and all expenses of the whole electric division
T_{total}: total maintenance time of the whole electric division
T_1: maintenance time for maintenance item 1
S_1: labor cost and expense for maintenance item 1

$$S_1 = T_1 \times \frac{S_{total}}{T_{total}}$$

Incorporation into the initial cost should be implemented in accordance with the accounting rules established for the whole Hanoi Metro. The system in which accounting is conducted in accordance with such accounting rules is called internal control. Internal control is intended to prevent fraudulent accounting, achieve accounting that can be used for managing the effectiveness and efficiency of operations, and increase reliability, etc. of accounting and financial reporting.

(3) Cost of the required maintenance items

Since the cost of the required maintenance items is the sum of the material cost, labor cost and expense required for the maintenance works, it can be calculated as follows based on the material cost M_1 calculated earlier and the above.

Cost of the required maintenance items

$$= M_1 + S_1 = \frac{X}{(a+c)} + \frac{Y}{(a+b)} + \frac{W}{(a+b+c)} + T_1 \times \frac{S_{total}}{T_{total}}$$

(4) Comparison between the cost for direct conduct and the outsourcing cost

The cost in case of direct conduct is as indicated above. In case of outsourcing, an outsourcing cost shall be added to the items. Even in case of outsourcing, operations such as order placement and completion inspection must be directly conducted, and there will still be items for labor cost and expense. Therefore, the cost of the required maintenance items is calculated as follows.

$$\text{Cost of the required maintenance items}$$

$$= M_{\text{outsourcing}} + S_{\text{outsourcing}} = \text{outsourcing cost} + T_{\text{outsourcing}} \times \frac{S_{total}}{T_{total}}$$

(5) Another viewpoint of cost calculation

The above are the methods for calculating the initial cost as performed by the electric division. Implementing operational improvement of each division as an index is an effective method for improving the company's management quality. However, there is another way of thinking that only the initial cost of the whole Hanoi Metro should be grasped. Decision of which approach to take should be based on the business policy. In case of the latter, the electric division will only implement the cash flow management. In case of direct conduct, the material cost shall be managed. In case of outsourcing, the outsourcing cost shall be managed.

3. Reference material

The following exemplifies the formulation of account titles based on the railway business accounting standard in Japan, as a reference material.

Since only costs will be incurred at the electric division, attention should be focused on the classification on costs. Under the Railway Business Accounting Rules, cost classification is defined as shown in Table 4.

Table 4 Cost classification under the Railway Business Accounting Rules

Cost classification			
Current expense	Railway business operating cost	Transportation cost	Line preservation cost
			Electric circuit preservation cost
			Car preservation cost
			Operation cost
			Transport cost
			Maintenance management cost
			Transport management
		Other costs	Guiding and advertisement cost
			Welfare facility cost
			General and administrative expense
			Taxes
		Depreciation cost	Tangible fixed asset depreciation cost
			Intangible fixed asset depreciation cost
	Non-operating expense	Cost incurred from non-operating activities (e.g., interest paid)	
Extraordinary loss		Loss temporarily generated due to a special cause other than normal business activity (e.g., loss on sale of fixed asset)	
Corporate tax, resident tax and business tax		National tax (corporate tax), local tax, etc.	

In Table 4, classification of costs related to electricity, communication, signals, and station equipment that the electric division will administer is as follows.

(1) Line preservation cost

Operation expense required for the maintenance of electric circuits of tangible fixed asset transport facilities (including substation machinery and communication machinery), cars (excluding special cars for railway track preservation), and all fixed assets excluding machinery for business use such as automatic fare collection equipment.

(2) Electric circuit preservation cost

Operation expense required for the maintenance of electric circuits of tangible fixed asset transport facilities (substation machinery, communication machinery and special cars for preserving electric circuits)

(3) Operation cost

Operation expense required for the operation of trains. Electricity purchase is included in this account title.

(4) Transport cost

Operation expense required for the handling of passengers, as well as the composition of trains and shunting operation. This includes cost of repair of machinery for business use such as automatic fare collection equipment.

(5) Maintenance management cost

Expense required for the management of maintenance work for tangible fixed asset transport facilities.

(6) Depreciation cost

Depreciation cost concerning railway business fixed assets, and a portion of the depreciation cost concerning fixed assets related to various businesses that the railway business bears.

In Table 4, classification of costs related to electricity, communication, signals, and station equipment that the electric division will administer is as follows.

The above cost classification shall be further subdivided into account titles, and cost shall be tallied for each account title. To help select the account titles required to calculate the initial cost at the electric division, Table 5 shows the account titles that constitute the above categories and the cost categories.

The repair costs shaded in Table 5 are recorded as material costs, and not recorded as expenses. However, this only represents sorting in terms of account titles in accounting. If costs (budget) of the division are to be formulated, the actually paid costs including repair cost shall be added up together.

The other shaded items are accounts regarded as not falling under the electric division’s operations. (The account titles included in the respective cost categories are checked.)

Table 5 Account titles and account items

Account title		Content	Account title					
			Line preservation cost	Electric circuit preservation cost	Operation cost	Transport cost	Maintenance management cost	Depreciation cost
Labor cost	Salary	**Basic wage**	✓	✓	✓	✓	✓	
	Allowance	Extra wage	✓	✓	✓	✓	✓	
	Bonus	Bonus, temporary salary, and reserve amount	✓	✓	✓	✓	✓	
	Retirement allowance	Retirement allowance, amount of reserve for retirement allowance	✓	✓	✓	✓	✓	
	Legal welfare cost	Amount borne by the business operator under the Health Insurance Act, Employment Insurance Act, and Workmen's Accident Compensation Insurance Law, etc.	✓	✓	✓	✓	✓	
	Welfare cost	Cost concerning welfare of employees such as medical affairs, sanitation, health, recreation, and cultivation	✓	✓	✓	✓	✓	
	Temporary employment wage	Salary for temporary employees	✓	✓	✓	✓	✓	

Account title			Content	Account title					
				Line preservation cost	Electric circuit preservation cost	Operation cost	Transport cost	Maintenance management cost	Depreciation cost
	cost								
Expense	Repair cost	Replacement material cost	Cost of repair items related to replacement asset	✓	✓				
		Outsourced replacement cost	Cost of outsourced repair related to replacement asset	✓	✓				
		Ordinary material cost	Cost of repair items related to asset other than replacement asset	✓	✓		✓		
		Ordinary outsourcing cost	Cost of outsourced repair related to asset other than replacement asset	✓	✓		✓		
	Fixed asset retirement cost		Temporary cost of operation line related activity such as discontinuance, excluding huge amounts	✓	✓		✓		
	Tickets, ledger reports		Cost required for tickets and ledger reports for station service				✓		
	Supplies cost		Cost of supplies and cost of equipment for works and office (including newspaper cost and library cost)	✓	✓	✓	✓	✓	

Account title		Content	Account title					
			Line preservation cost	Electric circuit preservation cost	Operation cost	Transport cost	Maintenance management cost	Depreciation cost
	Clothing cost	Cost required for clothing provided or lent	✓	✓		✓	✓	
	Power cost	Cost of power for operation (to be classified into electricity, fuel oil, etc.)			✓			
	Utilities cost	Cost of water, lighting, gas, petrol for heating, etc.	✓	✓	✓	✓	✓	
Expense	Ticket selling commission	Charge for commissioned sale of tickets				✓		
	Station cleaning cost	Cost for contracting station cleaning work				✓		
	Traveling expense and carfare	Transportation cost such as travel expense, train fare and bus fare	✓	✓	✓	✓	✓	
	Communication and transportation cost	Cost for communication such as postage and telephone charge, and for transportation	✓	✓	✓	✓	✓	
	Meeting cost	Cost required for meetings					✓	
	Expense-account	Cost required for entertainment, gifts, etc.					✓	
	Rental	Land rent, house rent,					✓	

	Account title	Content	Account title					
			Line preservation cost	Electric circuit preservation cost	Operation cost	Transport cost	Maintenance management cost	Depreciation cost
		movable property rent						
	Nonlife insurance premium	Nonlife insurance premium for tangible fixed asset					✓	
	Miscellaneous	Cost not falling under other titles	✓	✓		✓	✓	
	Tangible fixed asset depreciation cost (transportation facility depreciation cost)	Depreciation cost for fixed assets related to the railway business						✓
	Intangible fixed asset depreciation cost (business-related fixed asset)	Depreciation cost for fixed assets related to businesses other than the railway business						✓
	Intangible fixed asset depreciation cost (transportation facility depreciation cost)	Depreciation cost for fixed assets related to the railway business						✓
	Tangible fixed asset depreciation cost (business-related fixed asset)	Depreciation cost for fixed assets related to businesses other than the railway business						✓

Guidelines for preparing a list of items of maintenance operations to be conducted directly or outsourced

1. Purpose

Preparation of a list of items of maintenance operations to be conducted directly or outsourced would help administrators and maintenance personnel understand the outline of the maintenance works. Based on the list, the execution method and a work plan in the maintenance process will be formulated.

However, railway equipment must be maintained so that users can use the railway safely and stably with an easy mind. For its maintenance, the railway operator shall directly conduct inspections, repairs, etc. in principle. The direct maintenance by the operator enables it to diagnose and manage the operation state of the pieces of equipment that are most important in business operation. Such accumulation of experience would lead to maintaining and improving the technical strength.

2. Guidelines for preparation

2.1. Methodology

It is significantly important to classify equipment maintenance operations to be conducted directly or outsourced. The classification will not only facilitate the compliance with laws and regulations for equipment related to urban railways, but also enable the administrator of the OU electric division to prepare a list of maintenance operations to be conducted directly or outsourced based on the budget situation, the level of the maintenance personnel, etc.

When the list of maintenance operations to be conducted directly or outsourced is issued, the administrator will easily develop a work plan and implement it.

To prepare this list, it is necessary for the administrator to pay attention to major elements and issue a list at each development stage at the company.

2.2. Prerequisites for preparing the list

Criteria for preparing a list of items of maintenance operations to be conducted directly or outsourced are as follows.

1) Equipment subject to legal control

- Equipment for which laws/regulations concerning maintenance are established for a reason such as the possibility that conditions of the equipment may affect the safety of users or impair other equipment

- The maintenance of equipment subject to legal control shall be directly conducted by the railway operator in principle. If the maintenance is to be outsourced, it is necessary to carefully review the compliance with the legal conditions and then make a judgment.

  (Examples) Elevators, escalators, radio station equipment, etc.

2) COTS equipment (Commercial Off The Shelf)

- COTS is equipment that requires advanced expertise and devices for its maintenance. Maintenance operations such as equipment inspection, adjustment and repair shall be outsourced to the manufacturer or supplier of the equipment or a maintenance company that has advanced expertise, in principle. This is because conducting maintenance operations that require advanced technical requirements needs special measuring instruments and expertise.

- When the administrator prepares this list, he/she shall classify items of maintenance operations into those to be conducted directly or those to be outsourced based on the technical level of the maintenance personnel and the state of the accessory equipment company.

- For any maintenance operations that are conducted directly or outsourced, those operations such as equipment maintenance planning and management must be conducted by the railway operator.

  (Examples) Servers, management software, interface equipment, etc.

3) Equipment containing LRU (Line Replaceable Unit)

- Equipment generally consists of various LRUs. LRUs are devices that the manufacturer or supplier can replace ahead of time as necessary, as with modules. However, since LRUs are manufactured with blocks each containing multiple parts, it is difficult to maintain them. Conducting maintenance works that require advanced technical requirements needs special measuring instruments and expertise. Therefore, the maintenance operation shall be outsourced to the unit manufacturer or a maintenance company that has advanced technology or equipment in principle.

- For any maintenance operations that are conducted directly or outsourced, those operations such as equipment maintenance planning and management must be conducted by the railway operator.

  (Examples) IC units and reader/writer units

4) Non-important equipment (equipment not affecting train operation)

- Equipment whose condition or maintenance work may not substantially affect the safety of users and workers or convenience
- Equipment that requires simple maintenance work and will not affect train operation
- Equipment that falls under either of the above two items, and whose maintenance cost is higher than outsourcing

  (Examples) Equipment, etc. in office, employee lounge

5) Maintenance level

- General inspections (including temporary inspections with equivalent content): Inspections using sensor organ(s) that are conducted on an installed basis. They shall be conducted periodically, such as daily, weekly and monthly, according to the characteristics, usage, etc. of the equipment.
- Minute inspections (including temporary inspections with equivalent content)/repair: These inspections include minute inspections using tools or measuring instruments that are conducted on an installed basis, as well as adjustment, part replacement, and major repairs in which the equipment is overhauled after being transferred to the directly-operated maintenance factory, equipment manufacturer, or supplier. This

inspection shall be conducted for months or years according to the characteristics, usage, etc. of the equipment.

- Repairs: Repairs conducted on an installed basis, or conducted after the equipment is transferred to the directly-operated maintenance factory, equipment manufacturer, or supplier.

Based on the five items determined above, a table of maintenance operations to be conducted directly or outsourced can be issued as follows.

<table>
<tr><th colspan="2">Name of equipment</th><th rowspan="2">Equipment subject to legal control</th><th rowspan="2">COTS equipment</th><th rowspan="2">Equipment containing LRU</th><th rowspan="2">Non-important equipment</th><th colspan="2">General</th><th colspan="2">Minute insp./ major repair</th><th colspan="2">Repair</th></tr>
<tr><th>General</th><th>Minute</th><th>Directly operated</th><th>Outsourced</th><th>Directly operated</th><th>Outsourced</th><th>Directly operated</th><th>Outsourced</th></tr>
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</table>

Entry example:

Name of equipment		Equipment subject to legal control	COTS equipment	Equipment containing LRU	Non-important equipment	General		Minute insp./ major repair		Repair	
						Directly operated	Outsourced	Directly operated	Outsourced	Directly operated	Outsourced
Station server	Server		v			v			v		v
	Workstation		v			v			v		v
	Peripherals (e.g., printer)		v			v			v		v
Uninterruptible power source	UPS		v			v			v		v
	Battery unit			v		v		v			v
Lift	Escalator	v				v		v			v
	Elevator	v				v		v			v
Automatic Ticket Gate				v		v		v			v
Automatic Ticket Machine				v		v		v			v
Monitoring camera system	Camera unit		v			v		v		V[1]	
	Control system		v			v		v			v
Lighting equipment	Inspection					v		v		v	
	[Lamp replacement only]				v				V[2]	V[2]	

**1: If the camera unit fails, it will not be repaired, but replaced with a new camera unit.*

**2: For lighting lamps, preventive maintenance where they are replaced in a regular cycle shall be conducted in principle. Lamp replacement due to other reasons shall be conducted directly.*

Guidelines for formulating a business plan

4. Basic policy for formulating a business plan of the electric division

(1) Outline of a business plan

The purpose of formulating a business plan is to define a specific content of a company's business execution according to a management philosophy, a management policy, a medium-term management plan, etc. Depending on the company, a medium-term management plan is formulated on the basis of approximately three years, while a business plan, which is based on the medium-term management plan, is formulated on the basis of approximately one year. By making the framework of the formulated plan open to the public, the company holds up its promise.

A company's business plan is an integration of business plans that its divisions have formulated. A business plan at the electric division is formulated with the aim of securing safe, stable and secure operation of electric equipment. Examples include an overhead contact line replacement plan, a switch overhauling plan and an automatic ticket gate updating plan.

Corporate activity can be rephrased as repetition of formulating a medium-term management plan and a business plan in accordance with the company's management philosophy and management policy, and implementing the plans.

(2) Relationship with business plans of other divisions and the system for formulating a business plan at the electric division

The relationship with business plans of other divisions and the system for formulating a business plan at the electric division are as shown in Fig. 1. A business plan of the whole Hanoi Metro is a collection of business plans of the respective divisions, while a business plan of each division represents a collection of business plans of the respective staff in charge.

The process for formulating a business plan at the electric division (OU and HQ) is described below.

The OU electric division shall submit opinions and requests to the respective staff in charge at the HQ electric division based on daily maintenance. Specific examples include a request for advancing switch overhauling at a certain station and a request for simultaneously updating units of ticket gates.

The HQ electric division shall formulate a repair plan, updating plan, etc. based on the opinions/requests from the respective OU electric divisions, and on the useful life management ledger, equipment management ledger, etc.

Staff in charge of planning at the HQ electric division shall formulate an electric division business plan while coordinating with the medium-term management plan and business plans of other divisions as the overall supervisor/point of contact.

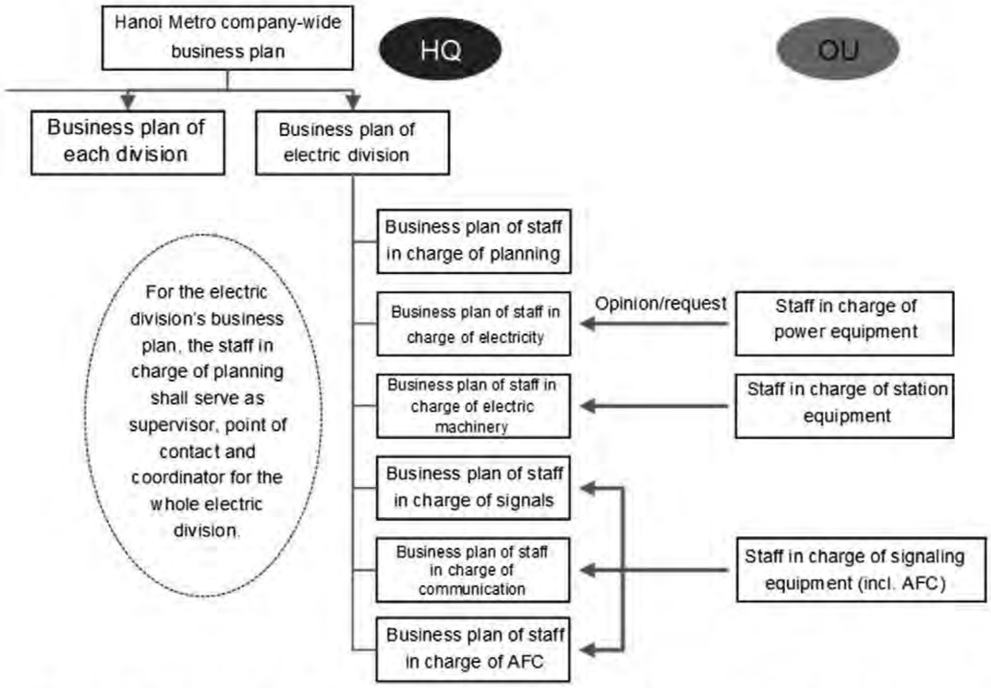

Fig. 1: Relationship with business plans of other divisions and the system for formulating a business plan at the electric division

* Characteristics of the electric division's business plan

The electric division's business plan shall be formulated in order to contribute to the management of Hanoi Metro under the following policies.

- Quality improvement through securing and improvement of safety, reliability and convenience in railway transport
- Operational efficiency improvement and cost reduction through operational improvement
- Social contribution through adoption of energy-saving equipment, etc.

5. Formulation of the electric division's business plan

2.1 Operation and maintenance of equipment

2.1.1 Equipment maintenance

a. Electric division of OU
   - Checking the description of equipment registered in the equipment management ledger with the actual state.
   - Conducting inventory inspection of equipment parts, work materials, etc., and formulating a purchase plan. Paying particular attention to parts, etc. for which manufacturer warranty periods are set.
   - Formulating a purchase plan also for equipment such as tools and measuring instruments.
   - For equipment with much failure, comparing a repair cost and an updating cost, and planning an effective action.
   - Summarizing the above, and submitting opinions/requests to the respective staff in charge at the HQ electric division.

b. Electric division of HQ
   - Checking the opinions/requests from OU, and conduct on-site verification as necessary.
   - Respective staff in charge shall formulate a business plan for repairs, updating, etc. based on OU's opinions/requests, useful life management ledger, equipment management ledger, etc. (coordinating with related sections of other divisions as necessary).
   - Respective staff in charge shall formulate a business plan for new equipment

installation, improvement, etc. based on the medium-term management plan, the company's measures, requests from other divisions, etc. (coordinating with related sections of other divisions as necessary).

- Staff in charge of planning shall finally formulate the electric division's business plan while coordinating with the medium-term management plan and business plans of other divisions as the overall point of contact/supervisor.

2.1.2 Budget

A plan for budgets required to implement a business plan shall be formulated.
In budgeting, acquire as much information as possible to calculate the appropriate price.

- Budget for maintenance (personnel cost, material and equipment purchase cost, etc.)
- Budget for outsourcing maintenance cost
- Budget for electricity purchase cost *(for the time being, the electric division shall formulate the budget, and purchase electricity in cooperation with the electric company)*
- Budget for communication cost incurred if an external line is used
- An equipment investment budget for new equipment installation, updating, etc.
- Repair budget for equipment inspection, repairs, etc.
- Budget for general expenses at the electric division (budget for education/training cost, business trip cost, office supplies cost, document management cost, etc.)

2.2 Investment plan

1) When the Line 2A is handed over and Hanoi Metro starts train service, depreciation of the equipment over which the electric division has control will begin, and after the completion of depreciation, generally equipment updating will begin. According to the provisions of laws/regulations and the manufacturer's specifications, a useful life management ledger for the railway equipment shall be prepared.
2) When the updating timing has come, it will become necessary to make a large equipment investment. When the scale of management of Hanoi Metro increases after the Line 2A starts train service, followed by the start of train service of the No. 3 and Line 2s, the amount of equipment investment will be further increased to substantially affect the company's management. Therefore, it is necessary to instruct OU to make follow-ups with the formulation of related documents and update them so that the company's investment plan will be ensured and sufficient equipment and materials will be supplied to the respective lines as necessary.
3) The electric division must fully grasp the useful life, operation state, etc. of equipment, and then define an investment plan from a medium-term perspective, and make up a detailed one-year investment plan in the business plan so that the investment timings will not be overlapped.
4) An investment plan relates not only to the useful life of equipment, but also to the state of equipment such as its failure rate. If equipment is maintained with a low failure rate even after the legal useful life is exceeded, it is not necessary to rush to updating.
5) In formulating an equipment investment plan associated with the start of train service of the Line 2A, examine whether or not a useful life of railway equipment is defined under laws/regulations of Vietnam, and if it is, apply that useful life. If a useful life is not defined under laws/regulations concerning railway equipment, determine a basic useful life based on the specifications, etc. that the manufacturer provides.

   There will be no data on an equipment failure rate, etc. in the beginning. Therefore, an updating time for each piece of equipment shall be set based on the useful life. The investment amount for the updating timing shall be estimated based on information on the equipment assets of the Line 2A, and the estimated amount shall be posted in the business plan.
6) Since the Line 2A will be basically transferred under a turnkey agreement, it is considered that there will not be a large equipment investment immediately after the transfer. However, since it may become necessary to extend or improve equipment according to the state of usage by customers, etc., it will be necessary to secure a certain amount of cost.
7) Fig. 2 shows an image graph of necessary cost, while Fig. 3 shows an image graph

of transitions in asset value and stability of equipment.

Fig. 2 provides an image of maintenance operation cost, updating cost, construction cost, etc. as the necessary costs on the assumption that the useful life is set at 10 years, 15 years, 30 years, etc. The construction cost represents the cost of new equipment installation, extension, etc., the updating cost represents the cost of equipment updating, and the maintenance operation cost represents the cost of inspection, repair, etc. Since this graph is prepared using dummy numbers, the ratios are also dummy.

Fig. 3 provides an image of assumed single piece of equipment for which the set useful life is 30 years and overhauling is conducted at the 15th year, in transition of the equipment's asset value and stability. The asset value decreases as the useful life elapses. Although stability also decreases as the time elapses, it will be recovered once through overhauling, and then decrease as the time elapses. Since this graph is prepared using dummy numbers, the ratios are also dummy.

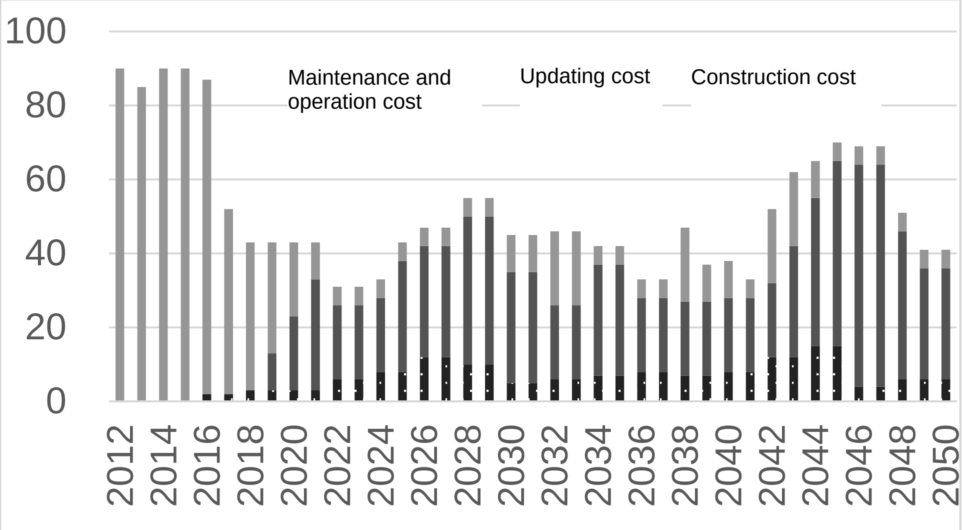

Fig. 2 Necessary costs

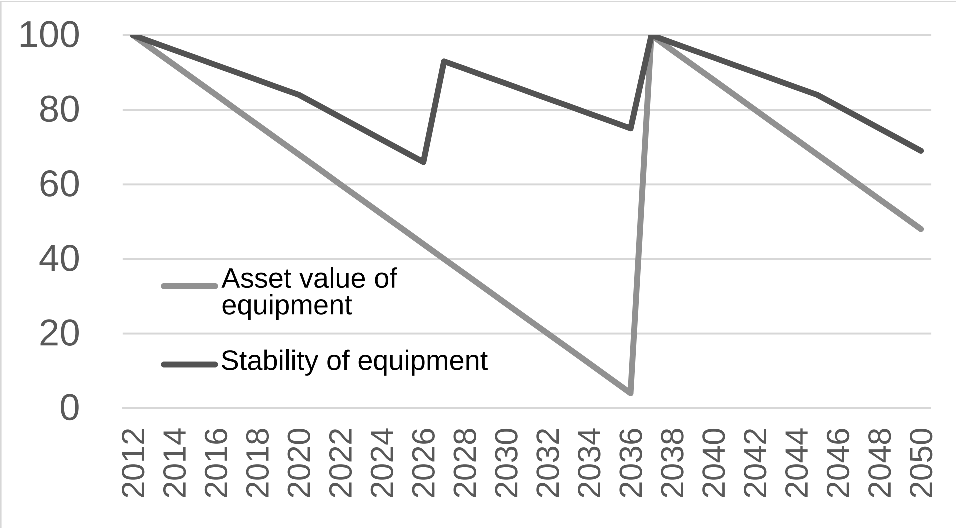

Fig. 3 Image graph in transition of asset value and stability of equipment

2.3 Equalization of a business plan and a budget

The electric division's business plan and budget include updating, improvement, new installation, inspection, repair, and removal, etc. of equipment, and can be formulated on the basis of 10 years, 30 years or 40 years if the policy is clarified. Useful lives of pieces of electric equipment are basically within 30 years, and it is important to equalize the plan and budget in the long term in order to eliminate year-on-year disproportion (or to prevent concentration in a certain year).

Since the ability to implement income and investment plans in the railway business is almost constant, it is important to equalize the budget. In addition, to implement the optimal investment plan, the difference between the budget and the result should be small. Therefore, it is necessary to collect as much information as possible, and prepare an appropriately sized (not too large, not too small) budget.

It is necessary to continually update information on technical innovation, and update information on equipment such as new installation, updating and improvement.

Fig. 4 and 5 show images of an un-equalized budget and an equalized budget.

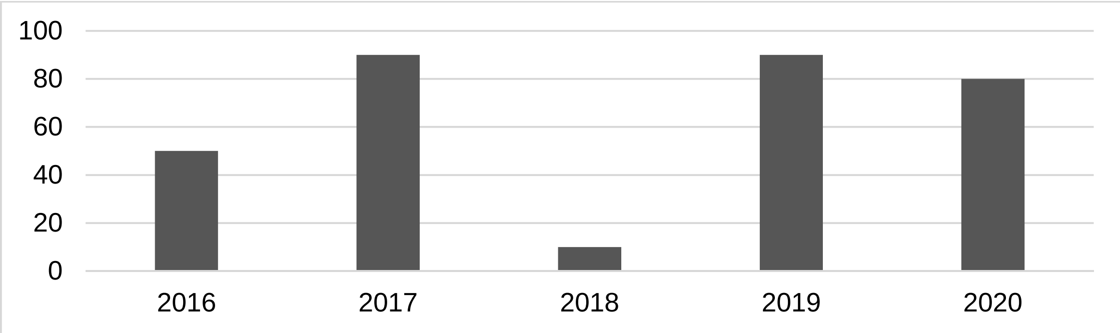

Fig. 4 Un-equalized budget

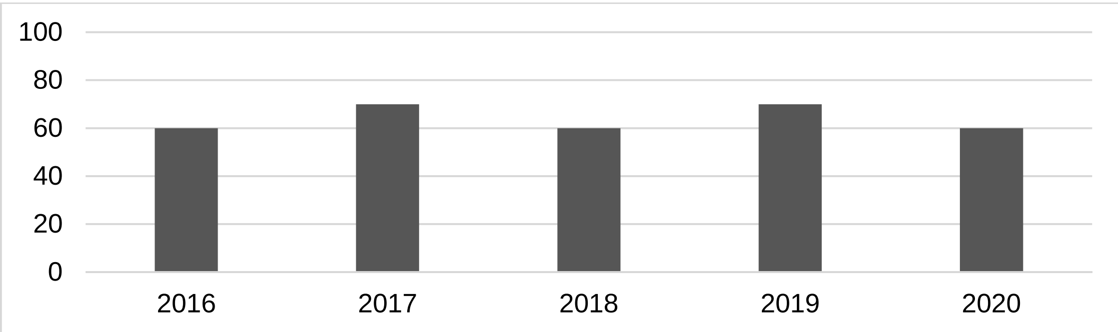

Fig. 5 Equalized budget

Budget planning for maintenance operations for the Line ○○○ - year ○○○
(electric division)

Maintenance time		Content of operation	Implementation method	Period of use	Maintenance cycle	Useful life	Implementing division	Implementation cost	Remarks
Month	Date								
Jan.	1								
	…								
	31								
Feb.	1								
	…								
	30								
Mar.	1								
	…								
	31								
Apr.	1								
	…								
	30								
May.	1								
	…								
	31								
Jun.	1								
	…								
	30								
Jul.	1								
	…								
	31								
Aug.	1								
	…								
	31								
Sep.	1								
	…								
	30								
Oct.	1								
	…								
	31								
Nov.	1								
	…								
	30								
Dec.	1								
	…								
	31								
								Total	

Interim budget planning for maintenance operations (electric division)

Month	Cost for implementing maintenance operations for all lines															Remarks
	Line ○○○			Line ○○○			Line ○○○			Line ○○○			Line ○○○			
	2016	2017	2018	2016	2017	2018	2016	2017	2018	2016	2017	2018	2016	2017	2018	
Jan.																
Feb.																
Mar.																
Apr.																
May.																
Jun.																
Jul.																
Aug.																
Sep.																
Oct.																
Nov.																
Dec.																
	Total: …..	Total: …..	Total: …..	Total: …..	Total: …..	Total: …..	Total: …..	Total: …..	Total: …..	Total: …..	Total: …..	Total: …..	Total: …..	Total: …..	Total: …..	
	Total			**Total**			**Total**			**Total**			**Total**			

Table of detailed cost for maintenance operations for the Line ○○○ - year ○○○
(electric division)

Maintenance time		Content of operation	Implementation method	Implementing division	Implementation cost						Remarks
Month	Date				Maintenance cost	Outsourcing cost	General cost at electric division	Electricity purchase cost	Cost additionally generated during maintenance	Others	
Jan.	1										
	…										
	31										
Feb.	1										
	…										
	30										
Mar.	1										
	…										
	31										
Apr.	1										
	…										
	30										
May.	1										
	…										
	31										
Jun.	1										
	…										
	30										
Jul.	1										
	…										
	31										
Aug.	1										
	…										
	31										
Sep.	1										
	…										
	30										
Oct.	1										
	…										
	31										
Nov.	1										
	…										
	30										
Dec.	1										
	…										
	31										
					Total: …..	Total: …..	Total: …..	Total: …..	Total: …..	Total: …..	
					Total						

Guidelines for preparing a renewal plan

1. Purpose

- The purpose of equipment renewal is to maintain/improve the stable operation of equipment, or implement necessary function improvements.

- The purpose of the renewal plan is to ensure that the company's overall plan (business plan and budget plan) will be followed, in addition to preparing a long-term maintenance work plan and maintaining stable operation of the equipment system.

- Equipment renewal shall be implemented in the following cases.

+ The useful life of the equipment has expired, and it is predicted or considered that the equipment may become unusable.
+ The equipment has failed, and it is predicted or considered that the equipment cannot be repaired.
+ There is demand for improving the operating capacity or function of the system.

2. Guidelines for preparing a renewal plan

2.1. Grounds for preparing/checking a renewal plan

- Laws and regulations concerning the equipment system

- The company's rules and overall plan

- Equipment management ledger and equipment useful life management ledger for each line

- State of budget for each line/year (to ensure budget leveling between years)

- State of equipment for each line

- Business plan of OU (long-term business plan, periodical inspection plan, repair plan, etc.)

2.2. The company's renewal plan format *(attached document)*

2.3. Annual renewal plan *(examined and prepared by OU)*

- OU of each line shall appropriately prepare an annual renewal plan based on the company's renewal plan and budge plan.

- Since equipment may temporarily fail, and be updated on an unscheduled basis, it is necessary to allow leeway when preparing a budget plan for each line or each year.

Updating plan
(Assume that the longest useful life among all equipment of the electric division is 30 years. Therefore, an updating plan for 30 years shall be prepared.)
Lines ...
Page/total page

Hanoi Metro Company

Classification	Name of equipment	Equipment code	Useful life	Installation site	Remarks	2016												2017												○○○												○○○												2046											
						Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug	Sep	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug	Sep	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug	Sep	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug	Sep	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug	Sep	Oct.	Nov.	Dec.
Electric power	....																																																																
	....																																																																
Electric machinery	....																																																																
	....																																																																
Communication	....																																																																
	....																																																																
Signals	....																																																																
	....																																																																
AFC	....																																																																
	....																																																																
Station equipment	....																																																																
	....																																																																

Guideline for Training/Education Plan Development for the Maintenance Personnel of the Line 2A Communication, Signal, Power and Station Equipment Sections

1. Policies
Purpose: This training plan shall be drawn up for the purpose of cultivation and enhancement of maintenance personnel ability along with clear directionality.

- The maintenance personnel of OU mean all of the managers, the deputy managers, the section engineers, the leaders, and the workers who belong to the communication, signal, power, and station equipment inspection and repair centers of OU.

Education: The role of education is to enhance knowledge, technology, and other capacities of human resources, aiming at raising the level of a whole organization by repeatedly providing education. The role of education is important in the railway business, since this industry is supported by a multitude of human resources. Without properly conducting education, there is no securing adequate human resources in terms of the number and quality.
- This education can be divided as follows:
+ Position based trainings (the manager training, the deputy manager training, the section engineer training, the leader training, and the worker training of the inspection and repair centers in OU)
+ Purpose based trainings (the transfer-staff training, the new-staff training, the theoretical/practical training, the handling training of tools for holding and equipment, the training to comprehend laws and corporate rules, etc.)
+ Trainings based on different methods (the on-the-job-training [OJT], the in-house training, the external training, training by external instructors, etc.)

Matters to be attended to in the maintenance personnel education process
- Analyze needs for education and types of individual ability, viewed from personnel management, which can be enhanced through the educational program at issue.
- Analyze an ability model for each position.
- Formulate details of education for each ability type.
- Compose educational modules by assembling educational contents.
- Develop plans so that they will become educational programs or models of the company.

2. Guideline for the formulation
2.1. Prerequisites for the formulation
Subject to:
- Development plans of the company
- Actual demand of the inspection and repair centers of OU
- Work ability of all the members of the inspection and repair centers of OU
- Business plans of the company (to implement education on technologies and equipment the company has decided to introduce)
- Yearly budget planning of the inspection and repair centers
- Applicable laws
- Personnel policies corresponding to laws and corporate development strategies

2.2. Division of educational plans
(1) External training plans
- Education plans based on individual demand: This is the education to be conducted with reference to subjective opinions of each member of the maintenance personnel. When a member realizes a weak point or ability he or she lacks, training to make up for it is planned. As a simple example, questionnaires should be distributed to all the maintenance personnel, a meeting should be held where a manager (OU) discusses related topics and the maintenance personnel express their views on necessary matters.
- Education plans based on real demand of the inspection and repair centers: When a manger (OU) finds a lack of knowledge or ability that the maintenance personnel have during the work process, he needs to do something to make up for it. The manager (OU) should propose an idea about an education plan of the personnel of a related inspection and repair center to a manager of a related equipment section of HQ.
    - Education plans based on corporate demand: Each inspection and repair center of OU should submit an education plan to a corresponding equipment section of HQ. The HQ side should submit the plan to the corporate management after discussions with the OU side.

The corporate management should draw up a company-wide common education plan along with its development directionality and development plan based on the submitted education plan. The inspection and repair center should formulate a concrete implementation plan and implement it based on the company-wide common education plan drawn up by the corporate management.

- Education plans based on opinions of the personnel department: The personnel department should propose a training and education plan of maintenance personnel with reference to a business plan of each department and ability of personnel, and then the department should submit it to the head of the company. However, to secure conformity, the personnel department needs to make arrangements beforehand with the head of each department and issue a proper and exact education plan.

(2) Internal education plans
- Managers (OU) need to deliver measures to improve work effectiveness of the inspection and repair centers with reference to actual work conditions and work ability levels of the personnel.
- Managers (OU) and deputy managers (OU), together with section engineers (OU), may assign homework to leaders and workers according to their knowledge, technology, and experiences in order to improve their ability. They should check results of the homework and provide necessary guidance.
- The managers of OU should guide leaders and workers by teaching knowledge and technology they have, in order to increase work ability and achieve high performance.
- Meetings for study, exchange of experiences, and the like should be held, while working out themes of the meetings and inviting all the personnel of the inspection and repair centers.

(3) Other education plans
- Education plans may be formulated in cooperation with business partners, equipment suppliers, etc. for the purpose of educating the maintenance personnel.
- Experiences can be exchanged and enhanced by sending maintenance personnel to external seminars.

2.3. Guideline for training/education plan development for the personnel of the inspection and repair centers
- Draw up training and education plans for personnel in line with the development directionality and development plan of the company.
- Draw up education plans based on demand and actual conditions of the inspection and repair centers.
- Ensure that all the personnel of the inspection and repair centers receive training on management and maintenance work so that their ability and levels of skills will be enhanced.
- Set specific conditions for personnel members who have higher ability and concentration for work as well as excellent quality, so that they can further enhance them.
- Proactively hold study meetings and seminars for all the personnel of the inspection and repair centers to exchange, share and learn their experiences.
- Issue policies to the human resources management of the inspection and repair centers on incentives and encouragement for enhancement of solidarity and full exercise of work ability of individuals and teams so as to achieve higher effectiveness during work time.
- Develop and maintain educational formats that can bring about a good effect.

Composition of criteria for installed quantity (for communication equipment, signal equipment, electric electric power equipment, elevators and escalators)

Purpose

If equipment is to be newly installed, extended, improved, updated, etc., installation criteria will be required and are essential.

However, equipment will have been installed when the Line 2A starts train service. Therefore, these installation criteria will not be applied. Nevertheless, equipment may be extended, improved or updated depending on the situation after the train service is started, and in such cases, these installation criteria would be adopted.

As with the Line 2A, these criteria will be applied when the other urban railway lines under construction and investment start train service. These installation criteria can be applied to those lines for which construction investment has not been made from the beginning. This way, criteria for the installed quantity of all lines in Hanoi City will be unified in the future. Since a technical standard law will be established in the future, it shall be promptly reflected after it is established.

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Part 4: Equipment installation criteria manual
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Part 1: Equipment standard rules

Criteria for performance and technical property of equipment intended to achieve safe, stable and secure passenger transport shall be established.

At this point, standard rules shall be formulated as rules common among all staff in charge and all lines. Subsequently, in the course of operation and at the time of construction investment in other urban railway lines, standard rules shall be formulated in the form of by staff in charge and by lines. The purpose of this is to respond to the actual situations of different lines because they have different equipment.

The equipment to be described in these rules shall be equipment involved in safe, stable and secure passenger transport.

Chapter 1. General rule

1.1. Purpose

Article 1. These rules are established with the aim of clarifying technical standard and performances of urban railway equipment in order to ensure safe, stable and secure passenger transport.

1.2. Scope of application

Article 2. The personnel of the electric division shall comply with these rules in addition to the applicable laws and regulations of the country.

Article 3.If a revision, addition, etc. on related content is made in any of the applicable laws and regulations of the country, updating, revision or addition must be made also in these rules for compliance and unification.

1.3. Definitions of terms *(in accordance with a standard for urban railways No. TCVN 8585:2011)*

“Railway signals” is a generic term of signals, signs and indicators.

Signals are a method for indicating conditions or instructions for operation and car shunting for trains and railway transport means, in the form of shape, color or sound.

Signs are a method for communicating information, commands and conditions on operation or car shunting that staff engaged in train operation conducted between railway staff, in the form of shape, color or sound.

Indicators are a method for providing necessary information on the display of the position, direction, condition, etc. related to railways, in the form of shape, color, etc.

Car gauge is a cross section range at which to permit the size of the train, etc. for securing a passage space for a train, etc. on a railway track.

Construction gage is a cross section range at which to permit installation of a building, etc. for a passage space for a train, etc. on a railway track.

Interlocking device is a device that links between signals, switches, and between a signal and a switch, etc. at places, etc. where collision or derailment could occur.

Electric train line is an electric line that supplies power to the train from a power collector. It contains a third rail, overhead contact line and rigid contact line.

Chapter 2. Railway tracks

Article 4. Equipment must be maintained in a state where the train can be safely operated at the prescribed speed. In other conditions, safety must be secured through speed limiting, monitoring, etc.

Article 5. A construction gauge shall be specified based on the car gauge. When installing equipment, be sure not to install those pieces of equipment that may be within the construction gauge due to deformation, deterioration, etc. even if it is outside the construction gauge.

Chapter 3. Electric power equipment

Article 6. An appropriate type of contact line shall be adopted based on the infrastructure of the respective line. If a third-rail system is adopted, a security measure must be taken for any place people can access.

Article 7. For a third rail, install protection equipment to protect people from touching it. In a station, a third rail shall be installed on the opposite side of the platform in principle.

Article 8. If scaffolds intended to be used for inspection of an electric train line and a feeder liner on the platform are to be installed, the height above the platform shall be ○○ m or more. However, this does not apply in cases such as those where the scaffolds can be stored inside, and a fence for preventing people from accessing the proximity of the place is erected (while referring to Tokyo Metro, the height was set at 1.8 m so that people with their hands raised will not touch the scaffolds on the assumption of an average [Japanese] height of 1.6 m).

Article 9. The rails for the return line shall be electrically connected at each joint by means of bonding or the like. The electric resistance at the joint shall not exceed the electric resistance of a 5 m portion of the rail.

Article 10. The strength and durability of the transmission line and distribution line shall be as indicated in the table below in accordance with the laws and regulations (values will be added when information on the Line 2A's equipment is acquired, and updated when a standard for urban railway operation and maintenance is published).

Strength and durability of transmission line and distribution line

	Strength	Durability
Transmission line		
Distribution line		

Article 11. An arrester shall be installed in the following places and their proximities.

- Places where lightning may affect related equipment
- Substation, receiving end and transmitting end of overhead transmission/distribution lines, and feeding end of overhead feeder

Article 12. Each substation shall have a fence, wall, etc. in order to prevent any person other than the personnel handling the substation from accessing it. A locking device shall be installed at the doorway, and a NO ENTRY indication shall be posted.

Article 13. Each substation shall have the following security equipment.

- Automatic breaker for protecting extra-high-voltage or high-voltage equipment
- Protection system against an overload and an abnormal electric current
- Equipment against fires

Chapter 4. Electric machinery and equipment

Article 14. Equipment, cables, switchboards, etc. must be installed in a manner to prevent short circuiting, ground fault, ground leakage, electrification and fires from occurring.

Article 15. For any place where short circuiting, ground fault, ground leakage, etc. may occur, a protector, monitoring device, alarm, etc. must be installed.

Chapter 5. Signal equipment

Article 16. For any railway, a device that secures an interval between trains shall be installed in order to secure safety between trains.

Article 17. For any cross section or branch of a railway track, an interlocking device shall be installed.

Chapter 6. Communication equipment

Article 18. A dedicated telephone with a private circuit shall be installed in any station, substation, OCC and any other places requiring it.

Article 19. To prevent communication between OCC and the train from being interrupted, a train radio device shall be installed.

Chapter 7. Related regulations and materials

Part 2: Equipment design manual

Chapter 1. Outline

1.1. Purpose

This design manual specifies a procedure for electric power equipment design, precautions, etc. This manual shall be prepared from the viewpoints of safety, reliability, operability, functions, cost, maintainability, etc. based on the equipment standard rules.

The design manual shall be prepared in the form of by staff in charge and by lines. At this point, the design manual is prepared in the form of by staff in charge of communication, signals, power and station equipment, and common among lines.

The equipment to be described in this manual shall be electric power equipment that the power inspection and repair center manages.

1.2. Outline of transforming equipment

Transforming equipment is intended to supply electric power to electric power equipment, station equipment, signal equipment, communication equipment, employee office, etc., and is installed in various places.

Electric power is received at a high voltage from the electric power company to a substation, which then steps down the voltage and transmits the stepped down voltage to contact lines and electric rooms at stations, etc.

In addition to stepping down a voltage, a substation rectifies an alternate current to a direct current, and supplies a direct current to contact lines.

Equipment, cables, etc. involved in transformation in a substation are transforming equipment.

1.3. Outline of electric line equipment

Equipment that supplies electricity from transforming equipment to contact lines and electric rooms of stations, etc. is electric line equipment.

1.4. Outline of electric facilities

Electric room equipment of a station to which electric power from the transforming equipment is supplied via electric line equipment is electric facility equipment. An electric room further steps down the received electricity, and supplies the stepped down electricity to various equipment installed in various places.

1.5. Equipment configuration drawing

Chapter 2. Power transformation

2.1. Philosophy

2.2. Design criteria

Chapter 3. Electric line

3.1. Philosophy

Electric lines in urban railways shall be highly reliable systems. Material, structure, characteristics of an electric line shall be fully considered also for the place/region where it is used and for the equipment alone. In addition, it is also necessary to pay much attention to the cost calculation at time of adoption.

3.2. Design criteria

3.2.1. Method for receiving electricity from the electric power company

The electric power company supplies electricity from a substation that it controls.

Electricity is transmitted via a cable from the substation that the electric power company controls, to a substation that HMC controls for supplying electricity to various equipment and trains. This cable shall be managed by HMC.

This shall be a three-phase AC three-wire system.

3.2.2. Distribution system

Basic distribution drawing

3.2.3. Cables

(1) Transmission/distribution lines *(the provided figures are tentative figures, and values will be added after specifications for the Line 2A’s transmission/distribution lines are obtained)*

Type	Conductor section area [mm^3]	Permissible current [A]	Transmission capacity [kVA]
CV (cross-linked polyethylene insulated vinyl sheath cable)	60	200	7,000

(2) Overhead transmission line

Type	Conductor section area [mm^3]	Permissible current [A]	Transmission capacity [kVA]
Hard drawn copper stranded wire	100	400	2,000

3.2.4. Contact lines
(1) Third-rail system
- Configuration diagram, material, related equipment, etc.
- Design guidelines (installation method, calculation method, installation site, installation layout, etc.)
- Precautions
- Procedures/method for application for approval with the government, and method for communicating them to the related divisions in the company

(2) Overhead wiring system
- Configuration diagram, material, related equipment, etc.
- Design guidelines (installation method, calculation method, installation site, installation layout, etc.)
- Precautions
- Procedures/method for application for approval with the government, and method for communicating them to the related divisions in the company

Chapter 4. Electric facilities
4.1. Philosophy
4.2. Design criteria

Chapter 5. Legends of symbols indicated in construction drawings

Part 3: Equipment order specification

An equipment order specification is intended to be attached to contract documents when a special order for a device or material is placed with the manufacturer after equipment is designed based on the equipment standard rules and the equipment design manual.

For railway electric power equipment, a product with special specifications or a special order product based on an ordinary product with enhanced specifications is used in many cases, and its production requires a specification describing the requirements of the equipment. Such a specification shall be prepared every time an order for equipment is placed.

This specification will be prepared in the form of by equipment and by lines. Those specifications requiring the company's higher technology than specifications issued under laws/regulations and by the supplier will be mentioned in this document.

When this document is prepared, a specification of a security camera (The security surveillance camera at the Vietnamese) used in the communication equipment shall be prepared in order to help grasp an image of the configuration of this document.

Chapter 1. General rule

1.1. Purpose

This specification specifies the equipment specifications of a security system designed to check the images from security cameras installed in stations. The owner shall request the contractor to produce the equipment based on this specification, while the contractor shall produce the equipment based on this specification.

1.2. Scope of application

This equipment specification shall be applied when the contract on the production of the equipment as indicated in this equipment specification is signed by the owner and the contractor.
If any deliberation or discussion on the content of the contract arises, the matter shall be examined between the parties. For important matters, a document that is mutually agreed on shall be prepared, and its copy shall be maintained by each party.

1.3. Applicable laws and regulations

If an order for the production of equipment is placed, the contractor shall follow the signed contract in accordance with the applicable laws and regulations and applicable standards.

1.4. Compensation matters

The contractor shall respond faithfully to any equipment failure attributable to the contractor, including a monetary burden.

The owner may not seek compensation from the contractor for equipment failure other than those attributable to the contractor.

Chapter 2. Equipment configuration

2.1. Drawing of the operating principle of the system

- Equipment configuration drawing
- Symbols, parameters, materials, etc.

2.2. OCC Center

(1) Image display device
- Controller
- Display
- System diagnosis device
- Power supply

(2) Image controller
- Controller
- Transmitter
- Power supply

2.3. Stations

(1) Image display device
- Controller
- Display
- Power supply

(2) Image controller
- Controller

- Transmitter
- System diagnosis device
- Power supply

(3) Image storage device
- Storage
- Duplicator
- Power supply

(4) Security camera
- Camera unit
- Transmission cable

Chapter 3. Functions

3.1. Function requirements

This system shall have a self-diagnosis function. The system's operating status shall be diagnosed at a constant cycle, and if an anomaly or a sign of anomaly arises, an alarm shall be output.

The startup and shutdown of this system shall be automatically performed in conjunction with the power supply. Even in case of power outage, system failure shall not occur, and manual operation of startup or shutdown shall not be required.

This system shall be composed of multiple systems. If the main system fails, it shall be automatically switched to the subsidiary system.

This system shall have a memory function at each station. At each station, the stored images can be checked at a later date/time. Even if images cannot be checked at OCC in case of transmission trouble, the images shall be stored at each station. The stored images can be duplicated and output to a disk.

3.2. Environmental requirements

This equipment shall have ordinary mechanical durability, electric durability, etc., and withstand long-term use in an office and an equipment room.

The metal material used for this equipment shall be provided with corrosion protection processing.

This equipment shall be provided with a rack so that it can flexibly respond to the installation space.

Heat dissipation shall be considered for this equipment.

3.3. RAMS requirements (reliability, usability, operability and safety)

Chapter 4.Specifications

The standard specifications to be described are as follows.
- Power supply voltage
- OS
- CPU
- Transmission capacity
- Camera image quality
- Strength
- Coating
- State of components constituting the system
- Redundant configuration
- Number of spares, etc.

4.1. OCC Center

Image display device
- Power supply voltage: 220 V AC + 10%
- OS: Windows 8 or higher (information on the Line 2A can be added when it is acquired; can be updated/improved to a better OS when technical development is achieved)

4.2. Stations

Chapter 5. Testing method and inspection method

5.1. Testing method

At the plant, a ○ day operation test shall be conducted (according to the rules and specifications provided by the firm). Some products may have been standardized. Here, assuming a special order product, a number of days that can be secured from production to delivery shall be set (approximately 30 to 90 days) (reference of Tokyo Metro).

During the operation test, the voltage, current, insulation resistance, etc. shall be measured.

During the operation test, outage-restoration operation shall be performed ○ times (according to the rules and specifications provided by the firm), to check the operation.

Example: Assuming that the equipment is used for 10 years in an environment where power outage occurs twice a month, power outage would occur 240 times. Therefore, outage-restoration test should be conducted approximately 300 times (rounded up from 240 times).

The test result shall be recorded in a document, and approval at an authorized level shall be obtained for the document recording the test result.

5.2. Inspection method

Inspecting the appearance (dimensions, components of equipment, etc.)

Inspecting the document recoding the test result

Reproducing the test result as necessary, and checking for consistency with the description in the record document

Recording the inspection result in a document, and obtaining approval at an authorized level of the contractor and the owner

Chapter 6. Spares, accessories, etc.

Operability and cost shall be weighed and the result shall be recorded.

Chapter 7. Documents to be submitted

Detailed specification of the delivered product, test result record, inspection result record, etc.

Part 4: Equipment installation criteria manual

This equipment installation criteria manual specifies the construction method, construction procedure, etc. to be followed in performing the installation as designed.

This manual shall be prepared in the form of by staff in charge and by lines. At this point, the manual shall be prepared in the form of being common among staff in charge and common among lines.

The equipment to be described in this manual shall be all equipment of the electric division.

At the time of preparing this document, a signal equipment installation criteria manual of the electric division shall be prepared as a reference material.

Chapter 1. General rule

1.1. Purpose

This manual specifies the construction method, construction procedure, etc. to be followed in the equipment installation for the electric division.

1.2. Scope of application

In performing the equipment installation for the electric division, the matters specified in this manual shall be observed.

1.3. Applicable laws and regulations

In performing the equipment installation for the electric division, the applicable laws and regulations shall be observed first, and then the company's equipment installation criteria manual and other applicable rules shall be observed.

Chapter 2. Site management

2.1. Administrator/responsible person

Responsibility and authority of the construction manager in the site

An construction procedure aimed at security during the work shall follow the laws and regulations, and can be additionally specified by the field manager with the aim of improving safety.

2.2. Materials

For the materials to be used, approval of the field manager or a superior shall be obtained.

For the supplied materials, their sources, etc. shall be clearly guaranteed.

2.3. Precautions for construction

2.3.1. Construction gauge

The cross section of the construction gauge shall be indicated.

2.3.2. Fire control actions

Regulations for fire control shall be observed.

It shall be ensured that the material meets the standards and requirements concerning fires.

2.3.3. Measures to prevent intrusion of rats and insects

Methods and measures to prevent rats and insects from affecting the equipment.

Chapter 3.Inspections

This manual shall contain a general inspection procedure.

Chapter 4. Standard construction (common among all equipment)

4.1. Equipment

Self-supported equipment
Wall-mounted equipment
Ceiling-mounted equipment

4.2. Cables

Storage trough
Storage rack
Metal cable

- Laying
- Cable connection
- Cable end connection

Optic cable

- Laying
- Cable connection
- Cable end connection

4.3. Coating

Coating standards
Coating method

Chapter 5. Standard construction (by types of equipment)

5.1. Signals

5.2. Switches
5.3. Indicators

Chapter 6. A collection of drawings
6.1. Legends of symbols indicated in the working drawings
6.2. A collection of drawings for the standard construction (sketch drawing, plan view drawing, cross-section drawing, etc.)

Chapter 7. A collection of photos
A collection of photos of the standard construction

Structure of Information Sharing Rules

Overview

This document presents proposed structure of a mechanism for improvement where the information sharing policy and the policy to make an equipment failure information database are actively applied and equipment failure information is actively used.

As these elements are strongly related to one another, they were compiled as single material when making the mechanism. Hereafter, when information is securely obtained and collection of necessary material is completed, the material will be divided into three different categories, and they will be compiled as rules for information sharing.

This material shall include the following content:

- Guideline for management and use of information

  This guideline shall be rules that specify how to manage and use information related to accidents, etc. In the rules, methods of collecting, storing, making widely known, and accessing information are specifically described as content.

- Guideline for recording data concerning failures, accidents, etc.

  This guideline shall be rules that specify methods of building and managing a database of information concerning accidents, etc. In the rules, formats and methods of inputting, storing, and accessing information are specifically described as content.

- Guideline for the PDCA cycle and operation quality

  This guideline shall be rules of operation enhancement processes where the PDCA concept is adopted.

Volume 1: Rules of how to manage and use information

Chapter 1 General rule

1.1 Purpose

These rules are formulated here for the purpose of specifying methods of managing and using information on accidents and the likes that have occurred in order to ensure safe, reliable, and secure passenger transport in the electric division of HMC.

These rules shall be based on correspondence to “The rules of response to urban railway accident and transport trouble” of HMC and “The electric division’s internal regulations concerning response to urban railway accident and transport trouble” of the electric division of HMC.

1.2 Scope of application

These rules apply to the electric division of HMC.

1.3 Interpretation of terms

- HQ stands for the Head Quarters.
- OU stands for the Operation Unit.
- Personnel of the electric division refer to all staff members belonging to the electric division of HQ and OU.
- Accident refers to an event in which damage of some form occurs in train operation, railway facilities, passengers, employees, etc.
- Accident risk refers to an event that has not led to an accident as a result, but has a high possibility that it might turn to an accident.
- DSDT is an abbreviation of an urban railway.
- Urban railway accident refers to an accident in which trains collide with each other or other objects, derail, overturn, or failures of railway facilities, causing troubles in train operation and damage to human life or health or to an asset.
- Urban railway transport trouble means a problem that affects the railway operation, but does not result in damage to human life or health or to an asset.
- Prompt report means immediate reporting or communication of occurrence of an accident or the like, and corresponds to the prompt report format specified in “The electric division’s internal regulations concerning response to urban railway accident and transport trouble.”
- Interim report means reporting of status of investigation into an accident or the like as well as

emergency countermeasures or the like, and corresponds to the description of the interim report format specified in “The electric division’s internal regulations concerning response to urban railway accident and transport trouble.”

- Final report means reporting of results of investigation into an accident or the like as well as permanent measures or the like, and corresponds to the final report format specified in “The electric division’s internal regulations concerning response to urban railway accident and transport trouble.”

Chapter 2 Reporting

2.1 Reporting methods of prompt, interim, and final reports

When reporting on an urban railway accident and an urban railway transport trouble as well as an accident accompanied by grave damage, human death or injury, etc. as a prompt, interim, or final report, the Manager (OU) or the Deputy Manager (OU) should go off to HQ and make a report or explanation in writing to the Manager (HQ) and the Deputy Manager (HQ) in charge. Nonetheless, if a special instruction is issued by the Manager (HQ) or the Deputy Manager (HQ) in charge, it should be observed.

2.2 Method of reporting to OCC

Reporting to OCC should be made with the first priority on speed but accurately using telephone each time in principle. Care should be taken to make a report or explanation clear in consideration of 5W1H (when, where, who, why, what and how) so that it can be correctly communicated with words alone. However, as need arises, a written report, drawings, photos, and so on should be separately sent so as to facilitate understanding by other party.

Example: 8.1 Tues 10:15, at Line 2A Ha Dong Station, a signal device failure caused stop signal to continue to be indicated on No. 1 signal of the inbound line.

Chapter 3 Sharing

3.1 Information sharing in the electric division on accidents or the likes that occurred within the division

- The Manager (OU) should quickly promote information sharing within the electric division after reporting an accident or the like that has occurred to HQ. The Manager should fully use e-mail, network folders, etc. to deploy material such as written reports, drawings, photos and the likes. The Manager should add explanations, remarks and the likes to the material so as to facilitate understanding by those who are not familiar with the equipment, the location, etc. at issue.
- The Manager (HQ) should quickly promote information sharing within the electric division according to the preceding provision, if an administrative agency and competent authorities give a guidance, etc. when reporting to them the accident or the like that occurred.

3.2 Information sharing in the electric division on accidents or the likes that occurred in other divisions

- The Manager (OU) and the Deputy Manager (HQ) should promptly collect grave information related to accidents and the likes that occurred in other divisions and information related to the electric division, and promote information sharing within the electric division. The Manager should fully use e-mail, network folders, etc. to deploy material such as written reports, drawings, photos and the likes. In actual deployment, analysis should be made on points to make note of by assuming that they are related to the division where the Manager or the Deputy Manager belongs, and then these points should be added to matters to give guidance on later. The Manager should add explanations, remarks and the likes to the material so as to facilitate understanding by those who are not familiar with the equipment, the location, etc. at issue.

- The Manager (OU) and the Deputy Manager (HQ) should promptly provide other divisions with grave information related to the division where the Manager or the Deputy Manager belongs and information related to the electric division. Especially, information of an accident should be provided with the highest priority to a division that is deeply associated with the accident.

3.3 Meeting to share information on accidents and the likes

The Manager (HQ) should periodically (once a month or so) hold a "meeting of the electric division to share information on accidents and the likes." It is intended to prevent occurrence or recurrence of accidents and the likes by promoting information sharing and strengthening awareness of safety. If information sharing is urgently required, a meeting should be held on a temporary basis.

Organization of this meeting should be assumed by a person (HQ) in charge of planning.

3.4 Report of sharing information on accidents and the likes

The Manager (HQ) should (once a month, a half year or a year or so) issue a "report of sharing information on accidents and the likes in the electric division." It is intended to prevent occurrence or recurrence of accidents and the likes by promoting information sharing and deepening knowledge and understanding of members of the division. If it is urgently required to make information widely known or give guidance on it, a report should be issued on a temporary basis.

This report should be prepared by a person (HQ) in charge of planning.

The Manager (OU) and the Deputy Manager (HQ) should teach content of the report and lead discussions about it in the workplace.

Chapter 4 Others

Volume 2: Rules on making the database of equipment failure information

Table of contents

Chapter 1 General rule

1.1 Purpose

These rules are formulated here for the purpose of specifying a policy to make the database of accidents and the likes that have occurred in order to pave the way for safe, reliable, and secure passenger transport in the electric division of HMC. These rules shall be based on correspondence to “The rules of response to urban railway accident and transport trouble” of HMC, and to “The electric division’s internal regulations concerning response to urban railway accident and transport trouble” and “The rules of information sharing” of the electric division of HMC.

1.2 Scope of application

These rules apply to the equipment sections of HQ and OU.

1.3 Definition of terms

- HQ stands for the Head Quarters
- OU stands for the Operation Unit.
- Personnel of the electric division refer to all staff members belonging to the electric division of HQ and OU.
- Accident refers to an event in which damage of some form occurs in train operation, railway facilities, passengers, employees, etc.
- Accident risk refers to an event that has not led to an accident as a result, but has a high possibility that it might turn to an accident.
- DSDT is an abbreviation of an urban railway.
- Urban railway accident refers to an accident in which trains collide with each other or other objects, derail, overturn, or failures of railway facilities, causing troubles in train operation and damage to human life or health or to an asset.
- Urban railway transport trouble means a problem that affects the railway operation, but does not result in damage to human life or health or to an asset.
- Prompt report means immediate reporting or communication of occurrence of an accident or the like, and corresponds to the prompt report format specified in “The electric division’s internal regulations concerning response to urban railway accident and transport trouble.”
- Interim report means reporting of status of investigation into an accident or the like as well as emergency countermeasures or the like, and corresponds to the description of the interim report format specified in “The electric division’s internal regulations concerning response to urban railway accident and transport trouble.”
- Final report means reporting of results of investigation into an accident or the like as well as permanent measures or the like, and corresponds to the final report format specified in “The electric division’s internal regulations concerning response to urban railway accident and transport trouble.”

Chapter 2 Mechanism and formats

2.1 Mechanism

Each time an accident or the like occurs, its outline should be input to the database. *(If no dedicated software is prepared during initial phases, Excel files can be used for work and saving.)* For details, paper documents or separate data folders should be referred to. A storage place of the paper documents or the separate data folders should be described in the database.

2.2 Paper documents and data folders

As described in the preceding paragraph, reports of accidents and the likes, drawing, photos, etc. should be kept in paper documents and data folders.

2.3 Database format

Occurrence date	Category of accidents and the likes	Organization in charge	Line	Station, etc.	Overview	Storage place of paper documents	Storage place of data folders
Aug. 2, 2017	Urban railway accident	Electric machine	2A	Ha Dong Station	A station fire caused by ventilation system trouble	Book-room shelf a-23	[Network addresses, etc.]
Oct. 5, 2017	Urban railway transport trouble	Signal	2A	Cat Linh Station to La Thanh Station	A failure in signal data transmission equipment	Book-room shelf b-104	Ditto
Feb. 25, 2018	Accident	AFC	2A	Thai Ha Station	An automatic ticket gate failure	Book-room shelf c-245	Ditto
Dec. 20, 2018	Accident risk	Power	2A	Lang Station	Wrong wiring of distribution lines	Book-room shelf d-50	Ditto

Chapter 3 Input, check and storage

3.1 Input

Input to the database should be assumed by the Section Engineer (OU).

3.2 Check (approval)

A check (approval) on content of input to the database by the Section Engineer (OU) should be assumed by the Deputy Manager (OU).

3.3 Storage

After the Deputy Manager (OU) confirms (approves) content of input to the database by the Section Engineer (OU), the Section Engineer (OU) should store it.

Chapter 4 Others

Volume 3: Improvement rules by active use of information on accidents and the likes

Table of contents

Chapter 1 General rule

1.1 Purpose

These rules are here formulated for the purpose of specifying improvement methods by active use of information on accidents and the likes that have occurred in order to pave the way for safe, reliable, and secure passenger transport in the electric division of HMC. These rules shall be based on correspondence to “The rules of response to urban railway accident and transport trouble” of HMC, and to “The electric division’s internal regulations concerning response to urban railway accident and transport trouble,” “The rules of information sharing,” and “The rules of making the database of equipment failure information” of the electric division of HMC.

1.2 Scope of application

These rules apply to the electric division of HMC.

1.3 Explanation of terms

- HQ stands for the Head Quarters.
- OU stands for the Operation Unit.
- Personnel of the electric division refer to all staff members belonging to the electric division of HQ and OU.
- Accident refers to an event in which damage of some form occurs in train operation, railway facilities, passengers, employees, etc.
- Accident risk refers to an event that has not led to an accident as a result, but has a high possibility that it might turn to an accident.
- DSDT is an abbreviation of an urban railway.
- Urban railway accident refers to an accident in which trains collide with each other or other objects, derail, overturn, or failures of railway facilities, causing troubles in train operation and damage to human life or health or to an asset.
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- Prompt report means immediate reporting or communication of occurrence of an accident or the like, and corresponds to the prompt report format specified in “The electric division’s internal regulations concerning response to urban railway accident and transport trouble.”
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emergency countermeasures or the like, and corresponds to the description of the interim report format specified in “The electric division’s internal regulations concerning response to urban railway accident and transport trouble.”

- Final report means reporting of results (of investigation into an accident or the like) as well as permanent measures or the like, and corresponds to the final report format specified in “The electric division’s internal regulations concerning response to urban railway accident and transport trouble.”

Chapter 2 Mechanism and formats

2.1 PDCA (the PDCA cycle)

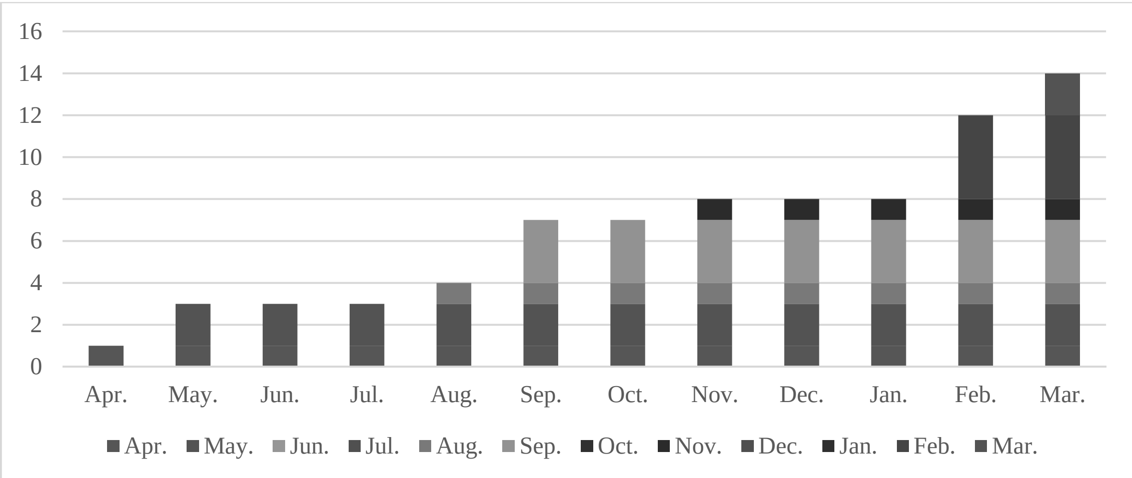
- Make use of PDCA for improvement where information on accidents and the likes is actively used.
  Plan (planning) →Do (execution) →Check (assessment) → Act (improvement)
- The object and the awareness of an organization can be made clear by setting KPI (Key Performance Indicators) as an improvement index.

2.2 Active use of PDCA

How to make use of PDCA is explained here by presenting case examples after Figure 1 and 2.

Due to use of case examples, the explanation is described along with the process of Check→Act→Plan→Do→Check→Act.

Figure 1. Monthly statistics of the accidents and the likes that occurred as attributable to the electric division in fiscal 2020



<u>Check</u>

- Figure 1 shows monthly statistics of the accidents and the likes that occurred as attributable to the electric division in fiscal 2020. The fiscal year total was 14 cases, while the number of occurrence in each moth was in a range between 0 and 4. It was confirmed (analyzed) that the months with high occurrence frequency are September (3 cases) and February (4 cases).
- In September, three cases of equipment failures occurred due to inundation of stations on typhoon days.
- In February, four cases of equipment failures occurred due to mishandling of subcontractor’s workers in subcontracted construction work.

Act

＋ Response to inundation

→ It was concluded based on analysis that the causes were the occurrence of the inundation in the stations and the installation locations of equipment that were affected by the inundation.

⇒ Countermeasures were taken with prevention of inundation of the stations and relocation of the equipment to locations that would not be affected by inundation.

＋ Response to subcontracted construction work

→ It was concluded based on analysis that the causes were a lack of personnel mobilization capacity of the subcontractor due to the increased number of construction work in February and a lack of prevalence of OU's supervision and guidance.

⇒ As a countermeasure, numbers of construction works for each month were equalized so that works did not concentrate in February.

Plan

＋ Response to inundation

→ The civil engineering and construction division planned construction work so as to prevent inundation.

→ The electric division planned equipment relocation to avoid an influence of inundation.

→ The term "zero cases of inundation damage per year" was set to KPI.

＋ Response to subcontracted construction work

→ A plan for subsequent construction orders was reviewed on the premise of equalization over months.

→ The term of "10 cases per month for the number of construction work orders" was set to KPI.

Do

＋ Response to inundation

→ The civil engineering and construction division executed construction works so as to prevent inundation.

→ The electric division executed equipment relocation to avoid an influence of inundation.

＋ Response to subcontracted construction work

→ The numbers of the following construction work orders were equalized over months.

Check

＋ Response to inundation

⇒ The yearly occurrence number of inundation damage became zero. (KPI satisfied)

→ It was confirmed that there was no fear of occurrence of inundation as a result of patrol made in the stations at issue during typhoons.

→ It was confirmed that there would be no influence on installation locations of equipment if inundation should occur in the stations at issue as a result of patrol made in the stations.

＋ Response to subcontracted construction work

⇒ It was confirmed that the numbers of construction work orders were equalized as the number per month became 9 to 10. (KPI satisfied)

→ The number of mishandling caused by subcontractor's workers in subcontracted works in February reduced from four to one.

Figure 2. Classification statistics of the accidents and the likes that occurred as attributable to the electric division between fiscal 2017 and 2019

Fiscal year	Power facility failure	Electro -mechanical equipment failure	Signal equipment failure	Communication equipment failure	AFC equipment failure	Attributable to workers	Attributable to passengers	Others
2017	3	2	1	3	5	8	0	0
2018	5	5	3	3	7	7	1	0
2019	6	3	1	3	7	9	0	0

<u>Check</u>

Figure 2 shows classification statistics of the accidents and the likes that occurred as attributable to the electric division between fiscal 2017 and 2019

It shows frequent occurrence of accidents that were attributable to workers.

<u>Act</u>

＋ Response to accidents attributable to workers

→ It was concluded through analysis that workers had insufficient understanding of equipment and work procedures.

⇒ A countermeasure against insufficient understanding by workers about equipment was taken so as to reinforce training in the workplace within OU.

⇒ A countermeasures against insufficient understanding by workers about work procedures was taken so as to review content of the maintenance manual.

<u>Plan</u>

＋ Response to accidents attributable to workers

→ Planning was made on programs and schedules of training in the workplace within OU.

→ Revision of the maintenance manual was planned while assigning persons in charge and setting a schedule.

→ The term of “five cases or less per year for the number of accidents attributable to workers that occur after taking countermeasures” was set to KPI.

<u>Do</u>

＋ Response to accidents attributable to workers

→ Training in the workplace within OU was carried out in a systematic manner for one year.

→ Revision of the maintenance manual was carried out in a systematic manner, taking one year.

<u>Check</u>

＋ Response to accidents attributable to workers

⇒ The number of accidents attributable to workers became five cases after taking the countermeasure. (KPI satisfied)

Act

＋ Response to accidents attributable to workers

→ It was concluded from analysis that KPI was satisfied and improvement was achieved but further improvement was needed.

⇒ A countermeasure against insufficient understanding about equipment was planned so as to reinforce training in the workplace within OU.

⇒ A countermeasure against insufficient understanding about work procedures was planned so as to further improve content of the maintenance manual.

2.3 PDCA format

The format is presented below.

PDCA sheet (example descriptions in blue)
Organization in charge: Persons of HQ in charge

Preview of Check	Date of filling out	Apr. 5, 2020
Three cases of equipment failures occurred due to inundation of stations on typhoon days in September of fiscal 2020.		
Preview of Act	**Date of filling out**	**Apr. 5, 2020**
- According to results of analysis, the causes were that the stations were inundated and equipment was placed in locations that were affected by inundation. ＋ Countermeasures were planned to prevent inundation of the stations and relocation of the equipment to locations that would not be affected by inundation.		
Plan	**Date of filling out**	**Apr. 20, 2020**
KPI: Zero occurrence per year of inundation damage		
- The civil engineering and construction division made planning of construction work to prevent inundation. - The electric division made planning to relocate the equipment so as to avoid an influence of inundation.		
Do	**Date of filling out**	**Jan. 15, 2021**
- The civil engineering and construction division carried out and completed the construction work to prevent inundation. - The electric division carried out and completed the equipment relocation work to avoid an influence of inundation.		
Check	**Date of filling out**	**Mar. 5, 2021**
- Zero occurrence per year of inundation damage (KPI satisfied) - It was confirmed that there was no fear of inundation as a result of patrol in the stations at issue during typhoons. - It was confirmed that there would be no influence on equipment installation locations if inundation should occur in the stations at issue as a result of patrol in the stations.		
Act	**Date of filling out**	－

Chapter 3 How to carry on PDCA

PDCA is a continuous activity. It is desirable for parties concerned to periodically check and share its progress by holding meetings, etc. For example, they may put in practice a method of having a person in charge report progress in writing in the meeting to share information on accidents and the likes, which is discussed in the Rules of Information Sharing (3.3 Meeting to share information on accidents and the likes).

Chapter 4 Others

Line 2A facilities management ledger

Policy for preparing a facility management ledger

- With the aim of achieving the purposes of managing the asset value and managing the useful life and attribute, a facility management ledger shall be prepared.

- Since two properties and applications are required for the facility management ledger, two types of ledger shall be prepared as follow.

  + The purpose of an asset value management ledger is to contribute to preparation of a financial statement and a balance sheet and management of the facility value (it shall be prepared or entered according to the finance division's instructions).

  + A facility useful life/attribute management ledger shall be utilized when providing information for the formulation of a business plan for the facility inspection/repair processes and searching for equivalent facility to be replaced with.

- The electric division shall prepare a "facility useful life/attribute management ledger." Create a format, and as soon as facility information is obtained, make entries.

- The format of the facility management ledger shall be created for each line and be shared among the respective staff in charge.

- To manage the facility's useful life, a facility useful life management ledger shall be prepared apart from the facility management ledger.

- For the saving of data into an electronic database of a facility management ledger and facility useful life management ledger, it is necessary to observe the laws/regulations and the company's rules.

Format for a facility management ledger (for each line/common among respective staff in charge)

Order	Name of staff in charge (1)	Name of facility (2)	Year of purchase (3)	Years of service (4)	Useful life (5)	Installation site (6)	State of facility					Purchase cost (12)	Manufacturer (13)	Facility code (14)	Year of manufacture (15)	Executing company (16)	Remarks (17)
							In operation (7)	Broken down (8)	Lost (9)	In stock (10)	Others (11)						
01																	
02																	

1. Policy for preparing an equipment useful life management ledger

- Preparation of an equipment useful life management ledger has the aim of managing equipment specifically from the viewpoint of its useful life.

<u>Format of an equipment useful life management ledger</u>

Order	Name of staff in charge (1)	Name of equipment (2)	Useful life (3)	Remarks (4)
01	Staff in charge of signal equipment	Switch	10 years	Body overhaul : 5 years
02				

Appendix 8-6-7-1-A(A) Structure of an AFC System (Equipment)

AFC (Automatic Fare Collection) means the automatic fare collection using IC cards. An AFC system consists of station service systems installed in the station and used by passengers and data processing servers that process data, all of which constitute an information processing network system. The AFC system generally has a five or six level hierarchy structure as shown in Figure 6-7-1, where the former uses the line server also as the operator server.

i) Level 5: Intercompany fare clearing system (CCHS)
ii) Level 4: Operator server
iii) Level 3: Line server
iv) Level 2: Station server
v) Level 1: AFC equipment
vi) Level 0: IC card

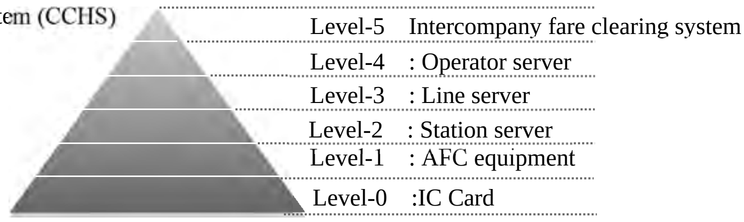


Fig. 6-7-1 AFC hierarchy model

The AFC system of Line 2A has Levels from 0 to 3. The operator server can be substituted by the line server of Line 2A until other lines such as Line 3 starts business. Table 6-7-1 shows the equipment used for each layer.

Table 6-7-1 Main AFC equipment

Layer	Relevant group	Main equipment	
5	Clearing Center	Clearing server	
4	O&M company	Operator server	
3	Line operation group	Line server	
2	Station	Station server	
1		Station service equipment	Automatic ticket gate (AG) Staff terminal (TOM) Add value machine (AVM) Automatic ticket vending machine (ATVM) Uninterruptible power supply (UPS) Yard AFC network equipment
0	Passenger	IC train ticket	Rechargeable IC card Single ride IC ticket Token

Besides the equipment included in these layers, we need to consider equipment for issuing IC cards and devices and equipment for educating and training staff. The former needs strict security control under an independent group, whereas the latter need specifications for education and training. In this survey report, we assume that relevant groups maintain and conserve these devices and equipment under appropriate standards, and deal with maintenance relevant to the equipment shown in Table 6-7-1.

Appendix 8-6-7-1-B(A) Basics of the Maintenance of AFC Equipment

1. Maintenance means all measures and actions to ensure continued operation of equipment and restore failures and defects. If equipment never malfunctions, no maintenance is needed. Almost all equipment, however, degrades its performance with the passage of operation time as shown in Figure 6-7-2 and eventually becomes inoperable.

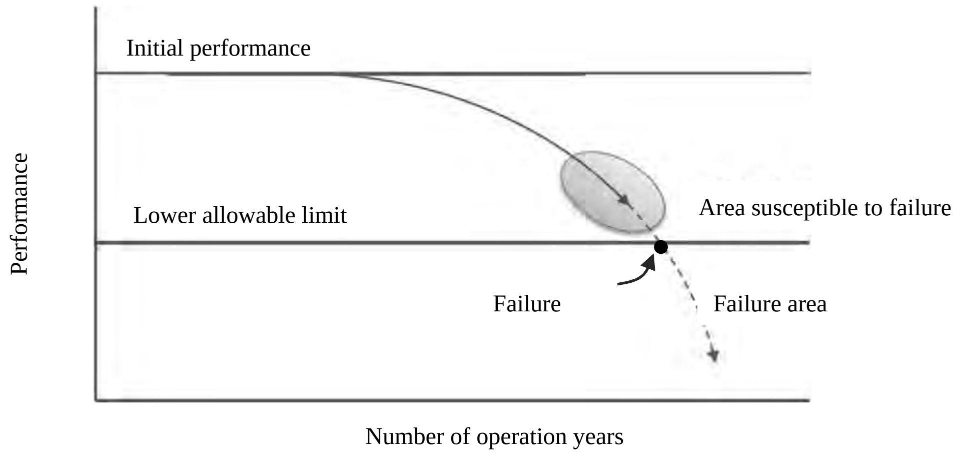


Fig. 6-7-2 Equipment operation and degradation

2. As shown above, maintenance is closely connected to failures, on which it focuses. It is important to take preventive measures before failures occur. Costs to prevent failures are generally lower than those to correct failures. As shown in Figure 6-7-3, preventing failures from occurring through maintenance is important. There are many types of failures. According to IEC 60050, major failure modes are defined as shown in Table 6-7-2. AFC equipment combines mechanical and electric devices to produce a desirable function, and hence a complex combination of the failures of component parts causes the equipment to fail. Consequently, periodic overhauling has been believed to be effective to prevent failures.

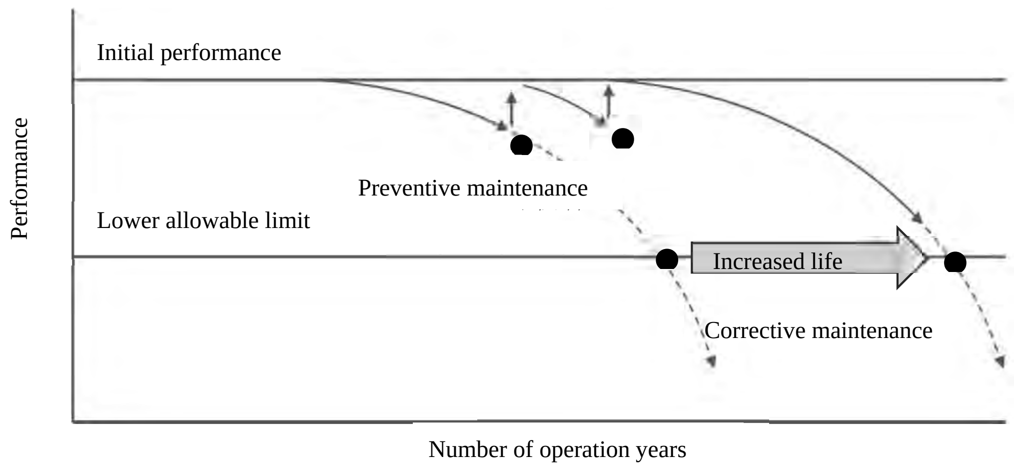


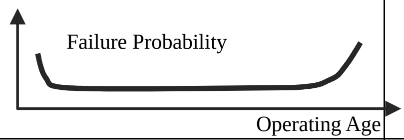
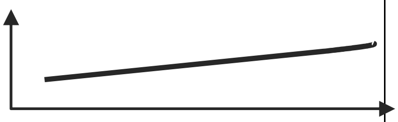
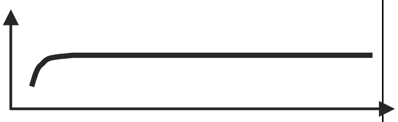
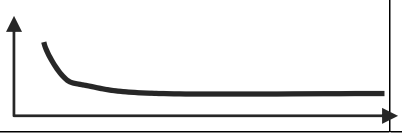
Fig. 6-7-3 Effect of maintenance

Table 6-7-2 Failure modes

No.	Classification	Definition
1	Gradual failure Drift failure	Failures occurring due to gradual change in equipment characteristics over time
2	Deterioration failure	Gradual and partial failures
3	Aging failure Wear-out failure	Failures whose probability of occurrence increases with time.
4	Catastrophic failure	Sudden failures causing all required functions of equipment to completely malfunction
5	Sudden failure	Failures unpredictable by means of pretesting or monitoring
6	Random failure	Failures randomly occurring after an initial failure period and before a wear-out failure period
7	Intermittent failure	Failures where equipment repeats a cycle of malfunctioning for a period and spontaneously restoring to its normal state
8	Single failure	Failures due to a single cause
9	Primary failure	Failures not directly or indirectly caused by the failures of other equipment, devices, etc.
10	Secondary failure	Failures directly or indirectly caused by the failures of other equipment, devices, etc.
11	Misuse failure	Failures occurring when equipment operates beyond its normal capacity, those due to design defects caused by the misuse of components, materials, etc., or those due to improper planning/implementation of tests, use, maintenance, etc.
12	Mishandling failure	Failures due to mishandling of equipment or lack of attention

In 1978, however, the survey report published by United Airlines clarified that overhaul was not effective on electromechanical equipment, but that condition-based maintenance was effective on it. Table 6-7-3 shows the results. The failure mode f) is found mostly in electromechanical equipment, accounting for 68% of all failures and having a high initial failure rate. Overhaul restores equipment to its initial state with a high failure rate, and hence it is not useful to prevent failures.

Table 6-7-3 Failure modes and their occurrence ratios

Type of failure mode		Relation between failure rate and operation time	Occurrence ratio
a)	Bathtub type		4%
b)	Initially constant and later gradually increasing type		2%
c)	Continuously increasing type		5%
d)	Initially increasing and then constant type		7%
e)	Constant type		34%
f)	Initially decreasing and then constant type (failure mode found mostly in electromechanical equipment)		68%

3. Classification of Maintenance

Figure 6-7-4 shows a maintenance structure. Each component is defined as follows:

(1) Preventive maintenance

Aiming to prevent equipment from failing during use, we carry out preventive maintenance based on specified intervals or criteria, and make a proposal on the functional deterioration or failure probability of equipment.

1) Scheduled maintenance:

   Preventive maintenance performed according to schedule.

   a) Fixed time maintenance: Preventive maintenance conducted at a fixed time interval.
   b) Age-based maintenance: Preventive maintenance conducted when the cumulative operation time of equipment reaches a predetermined time.

2) Condition-based maintenance:

   Actions to check equipment use and operating conditions during its use, detect the tendency of deterioration, identify failures and defects, and monitor operating values and their tendencies at certain time points to record the development of failures and for follow-up. Monitoring is conducted continuously, indirectly, or periodically by means of inspection, testing, measurement, and warning.

(2) Corrective maintenance:

Maintenance to restore the functions of equipment to the required operational level after detecting the failure.

1) Emergency maintenance: Maintenance conducted to restore the functions of preventive maintenance equipment when it fails.
2) Normal corrective maintenance: Maintenance to restore the functions of non-preventive maintenance equipment when it fails.

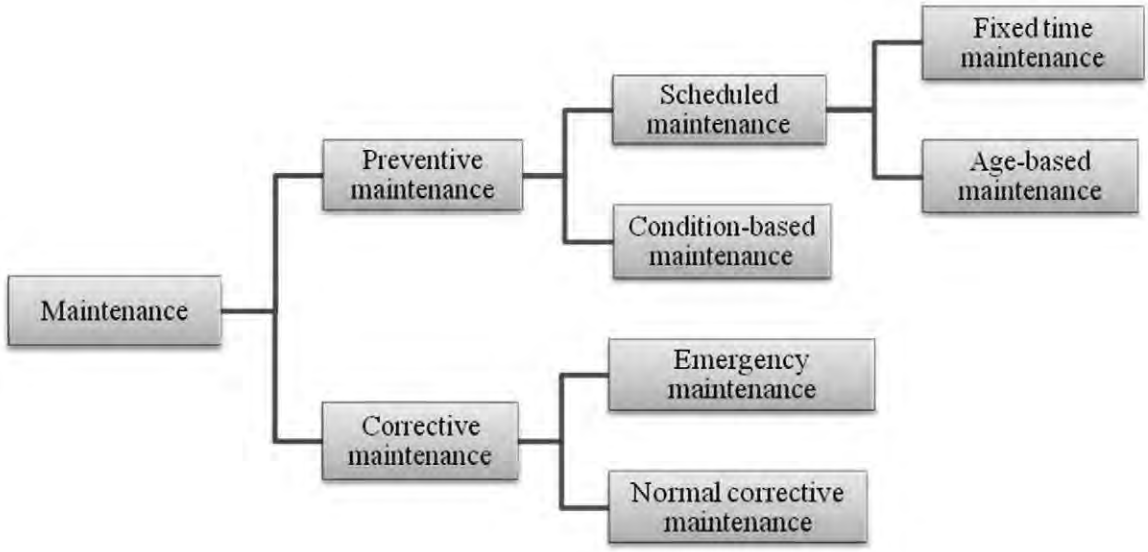


Fig. 6-7-4 Maintenance structure

Appendix 8-6-7-1-C(A) Maintenance Operation and Management

Maintenance is carried out through a system known as the PDCA cycle. The PDCA cycle shown in Figure 6-7-5 consists of the steps below. Implementing them one by one, we aim to improve the level of maintenance.

1. P: Plan [Development of a maintenance plan]
   Making a plan to implement the measures studied in the technical management below, we carry out design, estimation, order, and construction management needed for plan implementation. Preparation of an annual maintenance plan is also important.
2. D: Do [Implementation of equipment inspection, diagnosis, and maintenance]
   (1) To prevent the failure of equipment, some or all parts of it are disassembled or, if necessary, sent to a repair yard for maintenance in accordance with its installation/operating conditions or as necessary. Qualified persons must conduct the work based on predetermined specifications.
   (2) We diagnose the deterioration level and signs of failure of equipment by measuring its state quantity. The results enable us to take measures before a serious failure occurs.
3. C: Check [Collection and analysis of maintenance information]
   Based on the results of collecting and analyzing the effects of maintenance implementation (improvement of failure rates and failures intervals) and the state quantity after maintenance, we develop policies to improve equipment reliability. The formats of collected data need to be standardized and stored as a database to facilitate quantitative and statistical processing.
4. A: Act [Technical management]
   Based on various diagnosis data on deterioration state and their analysis results, we develop an annual maintenance plan including measures to improve maintenance quality and cost. The asset management of equipment is also important.

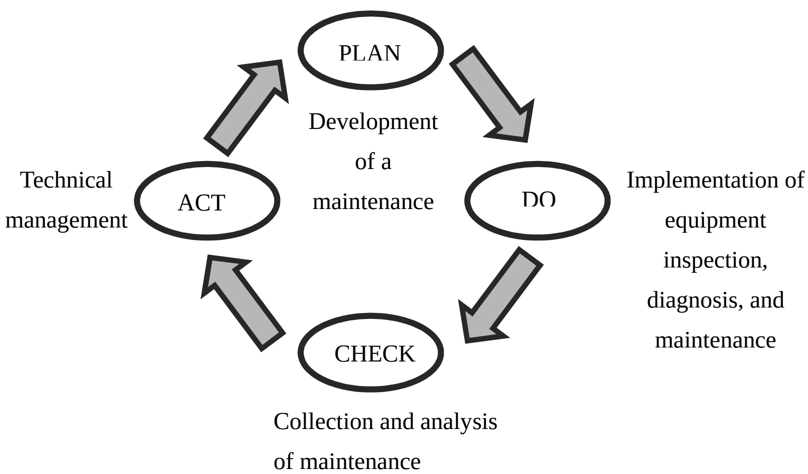


Fig. 6-7-5 PDCA management cycle of maintenance

Appendix 8-6-7-1-D(A) Organizational Functions to Implement Maintenance

1. General

Since circulating the PDCA cycle above enables the improvement of maintenance quality, we need the following organizations for implementing the PDCA cycle:

A: Technical management and planning: Planning group
P: On-site technical organization for equipment monitoring and diagnosis: Equipment technology group
D: Maintenance construction: Equipment construction group
C: Technology for equipment data integration and analysis: Equipment technology group

As described below, AFC equipment requires the unique characteristics of maintenance that are different from those for other equipment. We hence need to establish organizations responsive to these requirements.

(1) Being responsive to equipment operating for many hours without a break.
To contribute to society and support civic life as a social infrastructure, urban railways operates from early morning to late at night throughout the year with no break. It is hard to stop equipment operation to have maintenance time. An organizational approach to plan and implement highly effective work systems, such as nighttime work shifts and hierarchical maintenance, is thus needed.

(2) Emergency response to failures.
Failures occurring especially in the morning and evening commuting time have a high possibility of causing passenger flows serious trouble, and hence need to be immediately repaired. To this end, staff and work systems quickly responsive to failure occurrence are essential in addition to ordinary preventive maintenance systems.

(3) Availability of the same quality maintenance services for all train stations.
The network of Hanoi Urban Railway covers all of the metropolitan area. Consequently, all pieces of AFC equipment installed in train stations along the lines with 20 - 30 operation kilometers per line are dispersed and operated in the wide metropolitan area, and maintenance staff need to travel long distances. Means, such as locating the branch offices of the maintenance group at train stations distant from it, are essential to provide rapid and quality maintenance.

(4) Being responsive to simultaneous failures over a wide area.
Each piece of AFC equipment installed in train stations is connected to a large-scale network constituting the Hanoi Urban Railway network. An equipment failure may

therefore spread to a wide area through the network. Monitoring and controlling the network is hence important.

(5) Safe management of security data.
An AFC system handles a variety of valuable data such as fare information, clearing information, negative data, etc. Equipment malfunctions and failures may result in damaging, losing, and leaking these data, having enormous effects on passengers and railway operation companies. It is therefore essential to maintain the system highly effectively.

(6) Being capable of preventing theft and destruction.
As described in the previous paragraph, AFC equipment handles valuable data and holds data on its security maintenance. The equipment is, however, installed at a passenger-accessible location, i.e., it has high risks of theft and destruction. Besides security equipment, such as a shutter, to reduce these risks, systems for detecting and reporting equipment abnormality on a 24-hour basis are needed.

Figure 6-7-6 shows an example of the responses to AFC equipment failure installed in a train station and necessary organizational functions. (Most of AFC equipment is installed in a train station, and passengers use such equipment.)

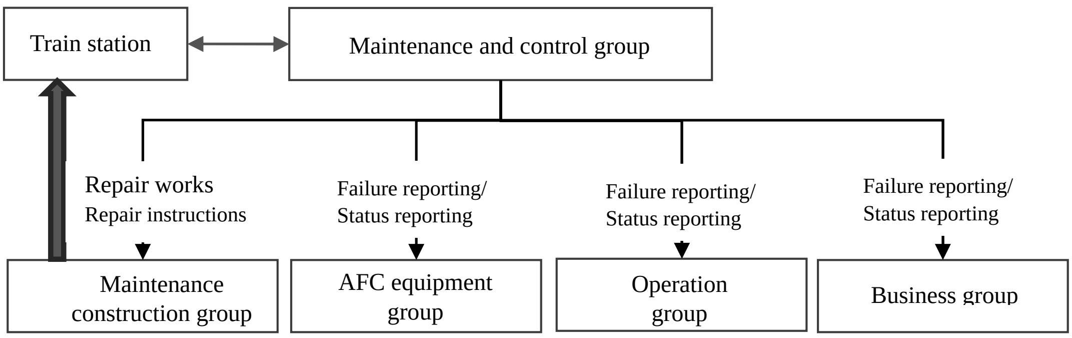


Fig. 6-7-6 Organizational response to AFC failure

When a failure of AFC equipment in a train station occurs, responses are as described below. It should be noted that, in addition to the repair of the equipment, passengers and operations are sometimes need to be dealt with. In such cases, a mechanism that relevant groups immediately work together with each other is needed.

(1) A failure of the AFC equipment occurs.
(2) The maintenance and control group receives a failure occurrence report from the train station.
(3) The maintenance and control group implements the following:

1) Instructing all maintenance construction groups to repair the failure.
2) Reporting the failure occurrence to the AFC equipment group.
3) Reporting to the train operation control group.
4) Reporting to the business group.

(4) The construction group rushes to the failure site for repair.
(5) In the case of a significant accident or failure, the technical group supports the activity.
(6) Train stations respond to passengers. In the case of a significant accident or failure, the business group supports the activity.
(7) When congestion in train stations increases and platforms are filled with passengers, the train operation control group carries out measures such as limiting train operations.

2. Organizations to Implement Maintenance

(1) Organization Structures

The previous section described the requirements for organizational functions. Many types of organizations can realize these functional requirements. Figure 6-7-7 shows a structure of major organizations relevant to AFC equipment maintenance by referring to the organization structure of Tokyo Metro, one of the world's largest urban railway companies (Tokyo Metro's company outline 2013).This organization structure covers all functions required for AFC equipment maintenance, where the telecommunications equipment group takes primary responsibility for AFC equipment management. located over a wide area, taking account of geographical or other factors.

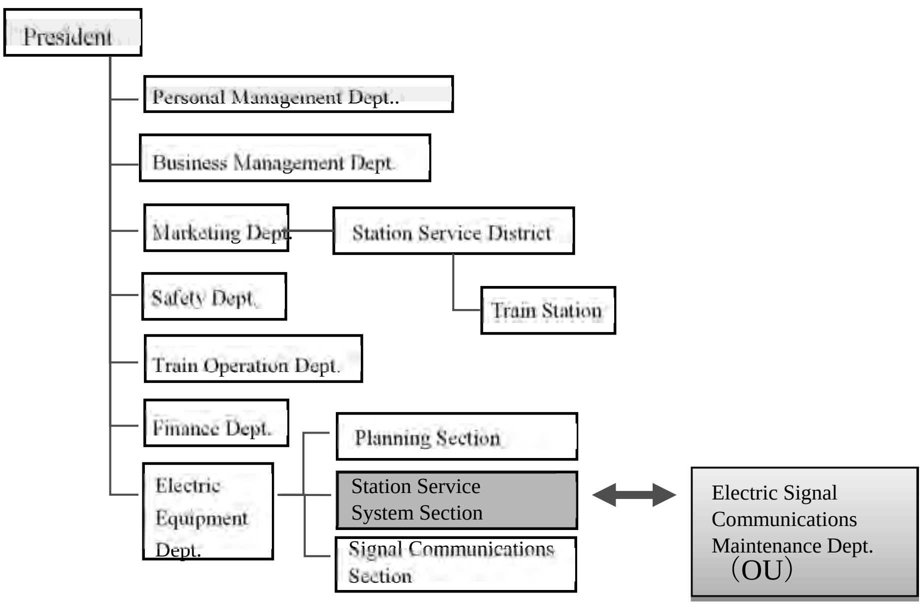


Fig. 6-7-7 Organization structure

The maintenance construction group is shown separately. In many cases, a subsidiary company or out sourcing can better carry out the maintenance of AFC equipment.

(2) Staff allocation

1) Staff of Telecommunications Equipment Department

AFC equipment maintenance consists of the work requiring technical expertise and that requiring management skill such as technical management analysis and planning, and the construction management of Maintenance Construction Group conducted for appropriating expenses. In the case of the organization structure described in the previous section, the Station Service Section needs a minimum of two persons: one for technology and another for planning and business management. The allocation of management resources, such as equipment renewal and investment, should be adjusted and planned based on the overall policy of the Telecommunications Equipment Department. The Planning Section under the direct control of the general manager of the Department takes charge of the work. The Section gradually increases the number of staff in accordance with the expansion of the urban railway network like the opening and extension of lines.

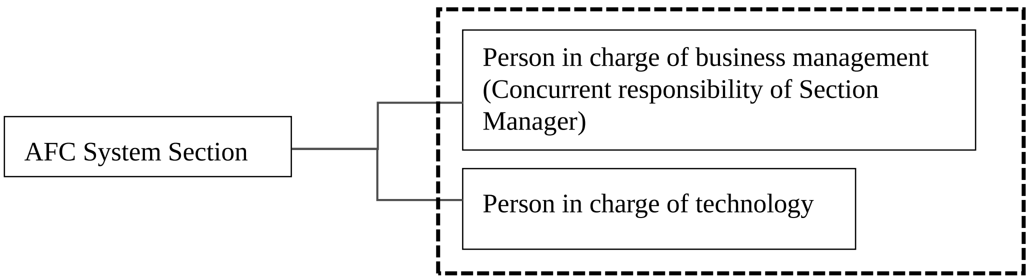


Fig. 6-7-8 Staff allocation of AFC System Section

2) Staff of Maintenance Construction Group

This group implements inspection, diagnosis, check, and repair based on maintenance plans. During business hours, passengers use AFC equipment. In rush hour, it is hard to stop equipment for preventive inspection due to tremendous congestion. It is hence desirable to carry out maintenance during nighttime after the closing of operations, where efficient work can be done. When a large-scale failure occurs in AFC equipment and when replacing or moving equipment, a large number of staff should be mobilized. Normal maintenance work, however, uses a relatively small number of staff. Setting the number of staff based on such cases results in having more staff than needed at normal times. It is therefore better to adopt shift work systems to allocate the number of staff needed for normal work and mobilize a necessary number of staff in an emergency such as the occurrence of accidents. There are many types of shift work systems. Since the Vietnamese Labor Law (10/2012/QH13) limits work hours to eight hours per day, the basis would be the four teams three shifts system. Table 6-7-4 shows an example of work shift systems.

Table 6-7-4 Four teams and three shifts system (example)

Work hours	Mo	Tu	We	Th	Fr	Sa	Su	Mo	Tu	We	Th	Fr
6:00-15:00	A	A	A	B	B	B	C	C	C	D	D	D
14:00-23:00	B	B	C	C	C	D	D	D	A	A	A	B
22:00-7:00	C	D	D	D	A	A	A	B	B	B	C	C
Absence	D	C	B	A	D	C	B	A	D	C	B	A

The number of assigned staff depends on the number of AFC equipment and maintenance work. Table 6-7-5 shows the number of major AFC equipment in Line 2A specified in the design plan of the line. The planned number of train stations is 12. The average number of AFC equipment per station is 25.
Maintenance work rules will be described later. Assuming here that the average time required for normal preventive maintenance work is one hour per unit, the required time per station is 25 hours.
Since AFC equipment is operated by passengers and its usage frequency is extremely high, the cleaning and checking of the equipment are important maintenance jobs. Periodic inspection is carried out at a cycle of about two months for equipment with the shortest maintenance interval. The maintainable number of train stations in the case of two months, i.e., 480 hours, is shown below. We can conclude that the period of two months can cover all train stations of Line 2A. It seems we have some surplus time, but such time is appropriate. The reasons are that equipment other than those listed in Table 6-7-5 is installed, and that we need to take account of the reduction in work efficiency during preparation for starting and finishing work, travel time, and business hours, and of mealtimes and breaks.

Table 6-7-5 Major AFC equipment of Line 2A and the number of the equipment

AFC equipment	Number of equipment	Number of equipment/station
Number of train stations	12	
Train station server	12	1
Train station monitor	12	1
Ticket server	12	1
Automatic ticket gate	139	12
Automatic ticket vending machine	96	8
Semi-automatic ticket vending machine	24	2
Total	295	25

- Maintainable number of train stations in two months
  480 hours÷25 hours/station = 19.2 stations

When having the four teams and three shifts work system shown above, at least three persons/team should be allocated as shown in Figure 6-7-9.

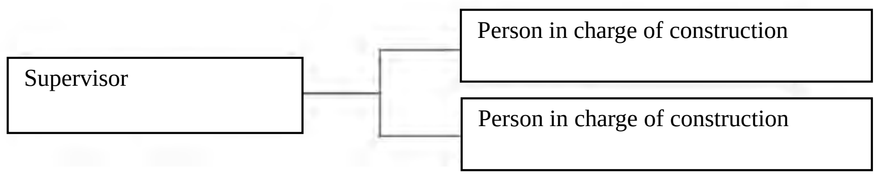
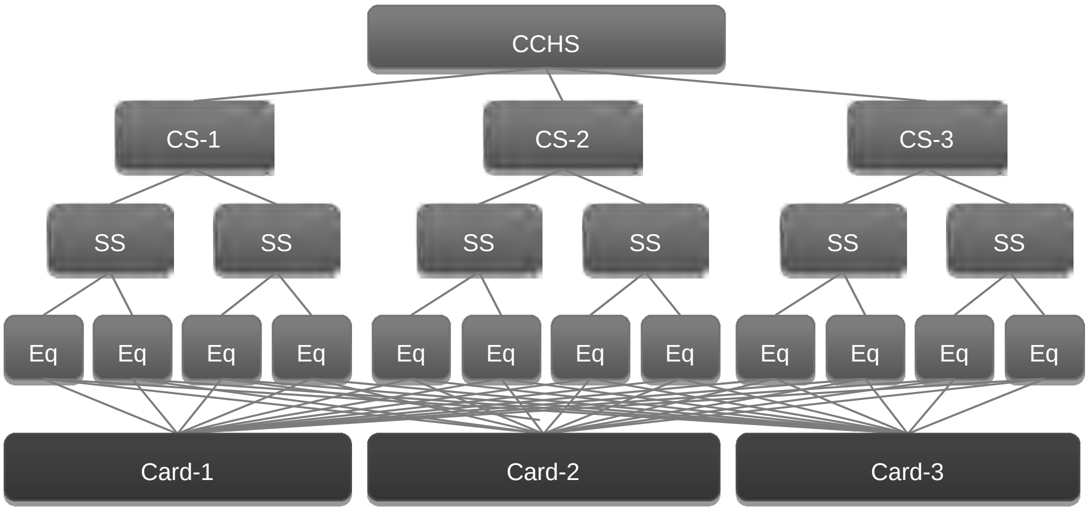


Fig. 6-7-9 Staff allocation at AFC System Section (in case of 3 persons/team)

Consequently, the total number of staff is 12. This number does not count that of absentees due to sick and vacation leaves. To avoid trouble in maintenance due to absences, allocating three persons per team to the position in charge of construction makes the total number 16. Allocating two staff members to the positions of business planning and operation management in the AFC Maintenance Construction makes the total number 18, which is the same number as that of the Line 2A staff allocation plan prepared by VNRA.

3) Staff of Control Group

All pieces of AFC equipment are connected to the network and constitute the AFC system shown in Figure 6-7-10. IC train ticket management data and boarding data are transmitted to this network, where the server of each layer processes data. Since network troubles may have effects on the entire network, we need to monitor equipment operation status, predict troubles, and carryout a rapid response.



CCHS: Clearing center　　CS: Operator server
SS: Station server　　Eq: AFC station equipment
Card: IC train ticket　　In the diagram, line servers are omitted for simplicity.

Fig. 6-7-10 AFC system structure diagram

Besides various work to be performed during business hours, the Control Group is responsible for data processing, such as clearing, after the closing of operations and for inspection before starting operations. It therefore needs a 24-hour control system.

It is better to perform AFC system control in the same group and place with other control organizations, such as OCC, rather than doing it alone, because cooperation with relevant groups is essential for troubleshooting.

Establishing a 24-hour system requires to allocate staff under the group leader of OCC. The minimum number of the staff is four, assuming that one person per one team. Taking account of absentees due to sick and vacation leaves, it is desirable to allocate five or six persons. The persons other than four mentioned above carry out work such as the management of the AFC control team as well as planning and data management on control.

Table 6-7-6 Structure of the AFC Control Group

Control work group	Number of staff	Work system
AFC control team leader	1	Normal work (filled when vacant)
AFC control staff	4	Shift work 1 person/team x 4 teams, 3 shifts

Appendix 8-6-7-1-E(A) Organization Rules

1. In a broad sense, AFC equipment is electromechanical equipment. To establish consistent reliability for the functions provided by electromechanical equipment, rules for the maintenance of AFC equipment should be developed based on common policies and concepts with mechanical equipment. Figure 6-7-11 illustrates this concept.

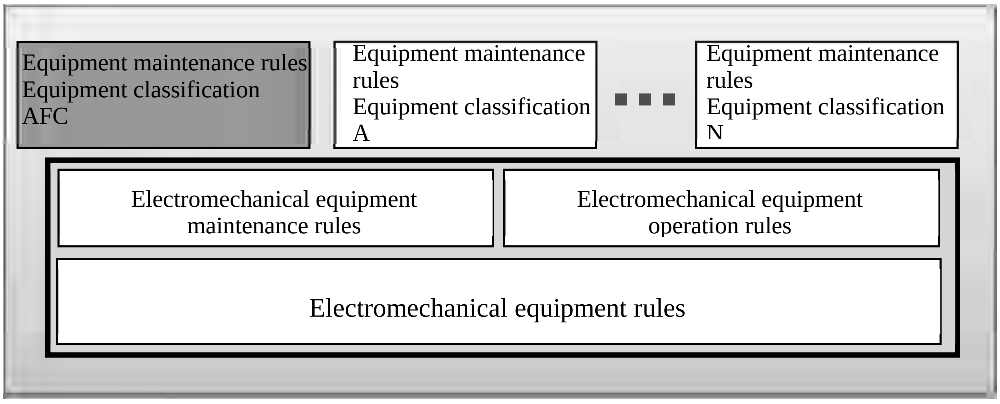


Fig. 6-7-11 System of AFC maintenance rules

2. Electromechanical Equipment Rules
   (1) Objective of Rules
   Aiming at the safety and sound management of railway transportation services, we establish rules to introduce proper equipment, operate it effectively, and maintain its normal functions.
   (2) Scope of Rules
   The Rules specify the procedures for the new construction, improvement, and maintenance of electromechanical equipment.
   Equipment asset management, equipment investment, etc. not included in the Rules shall comply with relevant rules specified separately.
   (3) Definition of Terms
   Electromechanical equipment is specified by Company Equipment Classification Table prepared separately. It does not include electric power machinery, communications equipment, medical equipment, and civil engineering machinery.
   (4) Maker of Rules
   General manager of Headquarters (HQ) Electric Signal Communications Department (train station equipment) shall establish the Rules.
   (5) Duties and Authority of the Maker of Rules on Rule Establishment
      1) Maker of Rules shall establish the following rules:
         a) Electromechanical Equipment Maintenance Rules

b) Electromechanical Equipment Operation Rules

2) Maker of Rules may establish standards on the following:

a) Design, scale (number of equipment, capacity), and technical systems for the new construction and improvement of equipment.

b) Construction such as the installation, renewal, abolition, and maintenance of equipment.

c) Work systems of technical management, such as equipment diagnosis, for maintenance.

d) Operation (handling) methods of equipment.

3) Maker of rules shall specify the enforcement period the Rules.

3. Electromechanical Equipment Maintenance Rules

(1) Objective of Rules

Maker of Rules shall establish the objective in accordance with the objective and rules specified in Electromechanical Equipment Rules.

(2) Scope of Rules

The Rules specify the maintenance of electromechanical equipment. The management of measuring instruments such as measurement equipment for maintenance and the appointment of the person responsible for equipment asset management not included in the Rules shall comply with rules specified separately.

(3) Definition of Terms

1) Maintenance means the following:

Maintaining the normal functions of equipment and improving its reliability and functions in accordance with the definition in 60050.

2) Technical management means the following:

a) Collecting and managing equipment data on the characteristic, deterioration state, and failures and their causes.

b) Analyzing equipment data for the development and implementation of plans to facilitate its life extension, reliability enhancement, and functional improvement.

(4) Person Responsible for Maintenance

General manager of Electric Signal Communications Maintenance Department in Passenger Transportation Group (OU).

(5) Duties and Authority of Person Responsible for Maintenance

1) Management responsibility

The person responsible for maintenance shall properly manage responsible equipment in accordance with the objective of the Rules.

2) Establishment of maintenance manuals

The person responsible for maintenance shall establish manuals on the maintenance practices of responsible equipment.

3) Improvement of maintenance efficiency and quality.

The person responsible for maintenance shall make efforts to improve the maintenance of equipment such as life extension, reliability enhancement, and functional improvement bases on the results of technical management.

4) Development of equipment management systems

The person responsible for maintenance shall establish and implement the systems on the following to ensure the completeness of maintenance work:

a) Management using the classification and identification code of equipment

- The person responsible for maintenance shall manage equipment using classes, models, names, identification numbers, and applicable codes (Tables 6-7-7 and 6-7-8) under the system that can uniquely identify equipment in accordance with rules for equipment asset management.
- The person responsible for maintenance shall mark the classification and identification code on all equipment.

Table 6-7-7 Classification and identification code format (example)

Class			Model			Name			Identification number				
1	2	-	3	4	-	5	6	-	7	8	9	0	A

Table 6-7-8 Classification and identification code (example)

Class		Model		Name	
10	Station equipment	10	AFC equipment	10	Two-way automatic ticket gate
20	Electric power equipment	20	Communications equipment	11	Wide automatic ticket gate
30				12	One-way automatic ticket gate
				20	Automatic ticket vending machine
				30	Automatic add value machine

b) Designation of important equipment

- The person responsible for maintenance shall designate the equipment assuming an important role in passenger transportation service as important equipment.

- The person responsible for maintenance shall take special measures to maintain the functions of important equipment.

c) Management of records

- The person responsible for maintenance shall register all equipment and properly store the drawings and technical documents of the equipment concerned.
- The person responsible for maintenance shall properly record and store all maintenance data and the history of all equipment.

5) Responses to serious accidents and failures
When a serious accident or failure occurs, the person responsible for maintenance shall immediately report the accident or failure to the general manager of Headquarters (HQ) Electric Signal Communications Department (trains station equipment), and carry out detailed survey reporting.

6) The person responsible for maintenance shall specify the enforcement period of the Rules.

4. Electromechanical Equipment Operation Rules

(1) Objective of Rules

Maker of Rules shall establish the objective in accordance with the objective and rules specified in Electromechanical Equipment Rules.

(2) Scope of Rules

The Rules specify procedures for the on-site use, installation, renewal, and abolition of equipment. Procedures for the abolition of unnecessary equipment not included in the Rules shall comply with relevant rules specified separately.

(3) Definition of Terms

1) The general manager of Headquarters (HQ) Equipment Group means the general manager of Electric Signal Communications Department (train station equipment) taking charge of equipment management, such as train station equipment, at Headquarters (HQ).

2) The general manager of Passenger Transportation Group (OU) means the general manager of the group taking charge of passenger transportation under control of Headquarters. Train stations with equipment belong to this Group, and their stationmasters are responsible for the station equipment at the point of use. Electric Signal Communications Maintenance Department is also belongs to the Group, and its general manager is responsible for maintenance.

(4) Management Responsibility for Equipment Operation

1) Responsibility of Headquarters Equipment Group

・Headquarters Equipment Group shall correctly understand the locations and operating status of all units of equipment, and manage them to ensure normal operation.

・Headquarters Equipment Group shall develop and manage plans for the operation (idling) and renewal of equipment.

2) Responsibility of Passenger Transportation Group

・The person responsible at the point of use shall appoint a person in charge for important equipment.

・The person responsible for maintenance shall instruct persons in charge of the points of use to operate equipment correctly.

・The person responsible for maintenance shall immediately take necessary measures when equipment operation is determined to be dangerous, and may order the person responsible at the point of use to stop operating the equipment.

・The person responsible for Passenger Transportation Group shall immediately report to the person responsible for Headquarters Equipment Group when idle or defective equipment is found.

・The person responsible for Passenger Transportation Group shall develop an abolition plan when equipment is found to be unnecessary, and dispose of the equipment in accordance with rules for asset disposition following the instruction of Headquarters Equipment Group.

3) The general manager of Headquarters Equipment Group shall specify the enforcement period of the Rules.

5. Equipment Maintenance Rules (AFC)

(1) General Rules

1) Roles of Groups

The organizations responsible for the work and construction required for AFC maintenance are Headquarters (HQ) Electric Signal Communications Department (train station equipment) and Electric Signal Communications Maintenance Department (OU) of Passenger Transportation Group. Work and construction that railway business operators cannot handle are sometimes outsourced to external contractors. In such cases, Electric Signal Communications Maintenance Department of Passenger Transportation Group shall take the role of the client as shown in Figure 6-7-12.

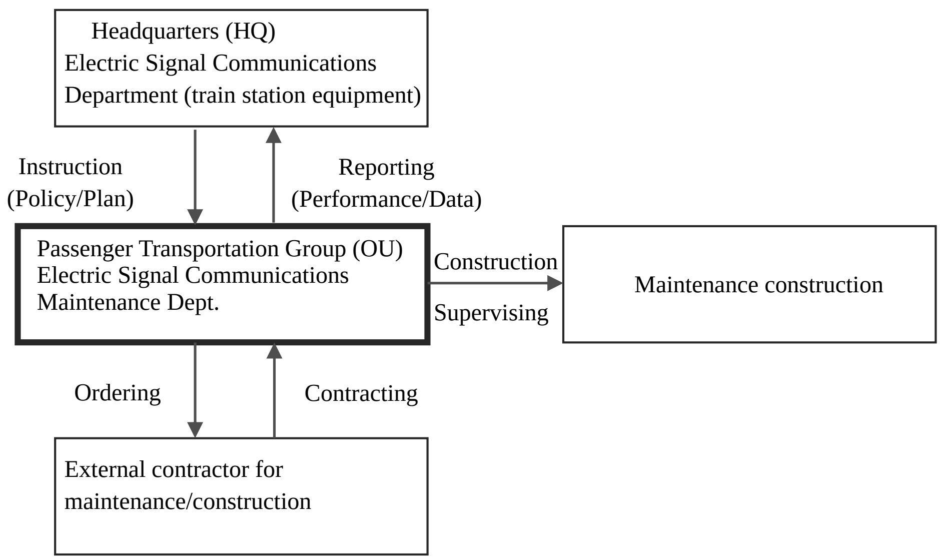


Fig. 6-7-12 Roles of relevant groups in maintenance construction

2) Scope of Rules

AFC equipment maintenance shall be carried out in accordance with the Rules

3) Relevant Laws and Regulations

Maintenance shall be carried out in accordance with the statutes established by Vietnam and Hanoi City in addition to the Rules, as well as the rules below separately provided by the railway business operator (Hanoi Metro) mentioned in the previous section.

a) Electromechanical Equipment Rules
b) Electromechanical Equipment Maintenance Rules
c) Electromechanical Equipment Operation Rules

The followings are relevant Japanese statutes. We should verify the Vietnamese statues concerned.

a) Construction industry Law
b) Building Standards Law
c) Labor Standards Law
d) Fire Services Law
e) Air Pollution Control Law
f) Water Pollution Control Law
g) Noise Regulation Law
h) Vibration Regulation Law
i) Industrial Accident Prevention Organization Law
j) Measurement Law
k) Industrial Safety and Health Law
l) Waste Disposal and Public Cleaning Law
m) Ministerial Ordinance for Determining Technical Standards for Electrical Appliances

Since maintenance work includes construction in the places close to business lines, the work should comply with the construction rules of the lines, in addition to the above.

4) Priority Order

When the rules, specifications, and design documents used for the maintenance of AFC equipment conflict with each other, determine priorities following the priority order below.

a) Priority order of Rules documents
   i. Electromechanical Equipment Rules
   ii. Electromechanical Equipment Maintenance Rules
   iii. Equipment Maintenance Rules (AFC)
b) Priority order of technical documents used for maintenance construction
   i. Documents on on-site explanations and questions and answers
   ii. Design drawings and special instruction documents
   iii. Equipment Maintenance Rules (AFC)

5) Definition of Terms

a) Maintenance construction

Maintenance construction means the construction to take measures (inspection, adjustment, repair, replacement, etc.) needed for maintaining the normal functions of equipment and improving its reliability and functions in accordance with the definition in IEC 60050.

b) Supervisor

The supervisor means the supervisory staff whose appointment is required by the Japanese Construction Industry Law. Appointed by the person who instructs (order) maintenance construction, the supervisor takes charge of supervising the construction concerned so that it is carried out complying with the design, plan, and rules concerned. Passenger Transportation Group (OU) assigns its staff as a supervisor when outsourcing maintenance work and construction.

c) Site representative

The site representative means the supervisory staff dispatched from the contractor whose appointment is required by the Japanese Construction Industry Law. Stationed in the construction site, the site representative takes charge of labor, process, and safety management. The contractor undertaking maintenance work and construction assigns its staff as a site representative.

d) Chief engineer

The chief engineer means the supervisory staff dispatched from the contractor whose appointment is required by the Japanese Construction Industry Law. The chief engineer takes charge of construction plan preparation, process management, quality control, and other technical management, as well as technical instructions to persons engaged in construction. The persons have an obligation to follow the instructions of the chief engineer. The contractor undertaking maintenance work and construction assigns its staff as a chief engineer.

e) Supervising engineer

The supervising engineer means the supervisory staff dispatched from the contractor whose appointment is required by the Japanese Construction Industry Law. The contractor shall appoint a supervising engineer when subcontracting construction with an amount exceeding a specified value to a subcontractor. Its duties are the same as those of the chief engineer. The contractor undertaking maintenance work and construction assigns its staff as a supervising engineer.

f) Special instruction document

The special instruction document means an instruction document describing the matters needed for maintenance construction, not mentioned in the Rules.

(2) Qualifications

AFC equipment is connected to a network and processes data for selling IC tickets to passengers, fare collection, access control to and from station yards, transactions, and passenger identification, and its failure and trouble have a tremendous effect on passenger transportation work. For this reason, persons with sufficient skills, experiences, and expertise specific to duties shall engage in maintenance construction. We shall therefore establish a qualification system to have the staff of Passenger Transportation Group (OU) certified by the general manager of Headquarters Equipment Group performs maintenance work corresponding to his or her qualifications. Table 6-7-9 shows examples of qualifications and corresponding duties.

Table 6-7-9 Qualification classification of persons engaged in maintenance construction

Qualification classification	Duty
AFC chief engineer	Supervising the AFC competent engineer to instruct technology and safety management in maintenance construction.
AFC competent engineer	Being assigned to each work group of maintenance construction as the person in charge of the group, and managing and supervising the group to perform construction safely and on accordance with the design, plan, and rules concerned. Taking a task as a supervisor in a construction site.

(3) Procedures Specified in Statutes

1) Notification
In Japan, construction such as equipment installation in maintenance construction, for example, is classified as the construction work specified in the Construction Industry Law (machinery installation work). After notifying the authorities of construction, the contractor shall carry out construction complying with the statutes concerned. The general manager of Electric Signal Communications Maintenance Department of Passenger Transportation Group (OU) has a responsibility to submit necessary notifications to the authorities concerned in accordance with the relevant Vietnamese statutes.

2) Attendance
In the case where statutes require the various inspections of maintenance construction by the concerned authorities, the AFC competent engineer shall attend the inspections.

(4) Management of Construction Sites
The AFC competent engineer has responsibility and authority to manage the construction site following the instructions of the AFC chief engineer in accordance with the Rules.

1) Clean, tidy, and organize
The AFC competent engineer shall organize, tidy, maintain, inspect, and clean materials, machines, and appliances to ensure maintenance construction with a high degree of safety.

2) Prevention of accidents, disasters, and pollution
   a) Ensuring work site safety
      i. Work site safety inspection
      ii. Use of safety equipment and safety protective equipment
   b) Items to check instructions to workers and implementation by workers
      i. Health check and clothes check
      ii. Correct and clear instruction of work contents and methods
      iii. Confirmation of correct methods to use tools and protective equipment
      iv. Instruction of safety procedures for train operations
      v. Instruction of prohibiting damage to architectural structures
      vi. Instruction of passenger safety measures during construction

vii. Instruction of preventive measures in the case of possible damage to architectural structures

viii. Instruction of a roll call in the cases of work in the vicinity of a business line, carrying in and out heavy loads, and high place work

ix. Clear indication of the classification of work under railway track closing as well as safety measures based on rules.

- Heavy load carrying work on the platform likely to enter into the construction limit performed during business hours. In this case, take measures such as placing a guard following the instruction of the person responsible for railway track closing.
- The similar work after the closing of operations is outside the classification of work under railway track closing. Entry into the construction limit is, however, prohibited.

c) Complaints from third persons

When third persons complain about construction, correctly understand the complaints, report to the supervisor, and discuss and implement proper measures.

d) Industrial waste

Industrial waste shall be disposed of in accordance with relevant laws and regulations. (In Japan, industrial waste disposal slips are stored for five years.)

3) Measures for the occurrence of accidents, disasters, and pollution

a) Worker

When accidents, disasters, or pollution occur, or they are likely to occur, and when urgent measures are required, workers shall immediately take proper measures and report to the supervisor, and follow his or her instructions.

b) Supervisor

The supervisor shall properly instruct workers, and report the circumstances to the AFC chief engineer and the general manager of Electric Signal Communications Maintenance Department, seeking their instructions.

c) AFC chief engineer

Based on the report from the supervisor, the AFC chief engineer shall consult with the general manager of Electric Signal Communications Maintenance Department to quickly issue necessary instructions.

d) General manager of Electric Signal Communications Maintenance Department
The general manager shall report to the general manager of Headquarters Telecommunications Department, seeking the instructions to handle the matters and successively reporting the results to the latter. In the stage of bringing them under control, the former shall submit to the latter a detailed report on the accidents, disasters, or pollution concerned with recurrence prevention measures.

e) General manager of Electric Signal Communications Department
Based on the report, the general manager shall issue instructions to relevant groups as necessary. The general manager shall also review the report in detail, examine the site if necessary, and take measures to improve future maintenance work.

4) Placement of supervisory staff

a) In light of relevant Vietnamese laws and regulations, the client shall place a supervisor in the site as defined in the Japanese construction Industry Law, and the contractor shall place a site representative, a chief engineer, and a supervising engineer in the site.

b) In accordance with relevant Vietnamese laws and regulations, the contractor shall report the names of its site representative, chief engineer, and supervising engineer to the supervisor before the start of construction.

5) Management of machinery and appliances
The responsible person shall carefully store and maintain machines and appliances needed for maintenance construction. Their handling and maintenance shall be carried out following the instructions of an experienced AFC competent engineer.

6) Management of electric power, gas, kerosene, and water
The responsible person shall apply in advance for the approval of the use of electric power, gas, kerosene, and water used for construction.

7) Preservation of the environment
The responsible person shall carry out the work described below to prevent damage to architectural structures under construction and preserve a safe

environment in the site. The AFC competent engineer shall instruct staff to carry out the work and take responsibility for implementing the work.

a) Curing

Curing shall be carried out before the start of construction to prevent damage to and contamination of architectural structures.

b) Clearing

Clearing, cleaning, and the removal of temporary construction shall be completed during the construction period.

c) Disposal of construction waste

Disposal of construction waste shall be carried out during the construction period.

8) Material management

a) Devices/materials

Maintenance construction shall use devices and materials with the quality, shapes, dimensions, properties, and functions enabling the maintenance and improvement of the functions of AFC equipment.

b) Approval of use

Maintenance construction shall use the devices and materials listed in the construction plan document, design document, and maintenance procedure manual prepared by the AFC chief engineer of Electric Signal Communications Maintenance Department, Passenger Transportation Group (OU), and approved by the general manager of the Department.

c) Management of supplied materials

When accepting the materials supplied by other groups, the AFC chief engineer shall prepare a receipt listing the name, quality, shape, quantity, place of receipt, date and time of receipt, person in charge of supply, and person in charge of receipt, and Electric Signal Communications Department of Passenger Transportation Group (OU) shall manage the materials. The general manager of the Department shall report to Financial Accounting Group of Passenger Transportation Group (OU) at the end of the term.

9) Construction

a) Plan document

The AFC chief engineer shall develop a plan document on AFC equipment construction quarterly, and the general manager of Electric

Signal Communications Maintenance Department shall obtain the approval of the general manager of Headquarters (HQ) Electrical Signal Communications Department for the document. In the case of emergency response to failures or troubles, the general manager of Electric Signal Communications Maintenance Department shall be able to instruct construction. Even in this case, the general manager shall report to the general manager of Headquarters (HQ) Electric Signal Communications Department (station equipment).

b) Change in the plan document

When changing the plan document, the general manager of Electric Signal Communications Maintenance Department, Passenger Transportation Group (OU) shall immediately report the proposed change to the general manager of Headquarters (HQ) Electric Signal Communications Department (station equipment), seeking the approval of the latter for the change.

c) Construction plan document

The AFC chief engineer shall prepare a construction plan document before the start of construction, and obtain the approval of the general manager of Electric Signal Communications Maintenance Department of Passenger Transportation Group (OU) for the document. When the construction may have effects on passenger safety, train operations, and station work, the general manager of Electric Signal Communications Maintenance Department of Passenger Transportation Group (OU) shall explain the plan to relevant groups before the start of construction, and take measures in corporation with the concerned groups.

d) Change in the construction plan document

When making a change in the construction plan document, the AFC chief engineer shall immediately report to the general manager of Electric signal Communications Maintenance Department (OU) and obtain the approval of the general manager for the change.

e) Maintenance construction

i. Details of construction

Equipment-wise inspection, adjustment, and their methods shall follow the maintenance procedure manual for each equipment separately specified.

ii. Duties of AFC competent engineers

- The AFC competent engineer shall prepare a construction plan document listing the date and time of construction, location of installation, name, and identification number of equipment by the day before construction, and obtain the approval of the general manager of Electric Signal Communications Maintenance Department, Passenger Transportation Group (OU) for the document.
- The AFC competent engineer shall seek the approval of the person responsible for the point of use of equipment for access and construction.
- When stopping equipment operation during business hours, the AFC competent engineer shall seek instructions from the person responsible for the point of use.
- As for items whose inspection is difficult after the completion of construction, the AFC competent engineer shall decide as a supervisory person whether to carry out testing and inspection, and carry out testing and inspection during construction if necessary.
- As for the testing and inspection and important items mentioned above, the AFC chief engineer shall decide as a supervisory person whether to carry out testing and inspection under the attendance the AFC chief engineers.

iii. Important construction

In the case of important construction having significant effects on passengers and train operations, the AFC chief engineer shall report to the general manager of Headquarters (HQ) Electric Signal Communications (station equipment) in advance and seek instructions from the general manager, under the instructions of the general manager of Electric Signal Communications Maintenance Department, Passenger Transportation Group (OU).

iv. Reporting during construction

- Based on the instructions of the AFC competent engineer, construction workers shall write the details of the day’s work in a report and submit it to the AFC competent engineer.

- The AFC competent engineer shall report the progress and details of construction to the AFC chief engineer.
- The AFC chief engineer shall report the progress and details of construction depending on the degree of importance to the general manager of Electric Signal Communications Maintenance Department.

v. Construction completion report

- At the time of construction completion, construction workers shall submit a report describing the details of construction, measurement values, and judgment results to the AFC competent engineer as a supervisory person.
- The details of consultations and instructions and their progress shall also be recorded.
- As for the items whose inspection is difficult after the completion of construction and conducted during construction, their inspection reports and data shall be attached to the report.

f) Completion inspection

i. The AFC chief engineer and the general manager of Electric Signal Communications Maintenance Department shall check the completion report and submit it to Headquarters (HQ) Electric Signal Communications Department (station equipment) for inspection.

ii. Headquarters (HQ) Electric Signal Communications Department (station equipment) shall perform site inspection as necessary.

6. Technical Certification Rules

(1) General Rules

1) Objective

Aiming to accomplish the objective of AFC equipment maintenance, the Rules intend to certify the staff with proper technical expertise as an engineer and have only qualified persons carry out technical work. The qualification certification system also encourages staff to learn technical skills.

2) Scope of Rules

Technical certification of the staff engaged in AFC equipment maintenance.

3) Definition of Terms

a) Maintenance management capability

The maintenance management capability means the knowledge and management capability required for maintenance management such as construction technology, quality, process, safety, and data management.

b) Technical skills for maintenance

The technical skills for maintenance mean the technical skills required for maintenance construction such as the mechanistic understanding, inspection, disassembly, improvement, repair, assembly, control, testing and adjustment of AFC equipment.

(2) Qualification Types

Table 6-7-10 shows the technical qualifications required for engagement in maintenance construction.

Table 6-7-10 Qualification types

Qualification type	Definition
Chief maintenance engineer	Person with the maintenance management capability of AFC equipment
Competent maintenance engineer	Person with the technical skills for maintenance of AFC equipment as well as the capability to perform the duties required for a supervisory person in a construction site
Maintenance engineer	Person with the technical skills for maintenance of AFC equipment as well as the capability to accomplish maintenance construction under the instructions of a competent maintenance engineer

(3) Requirements for Acquiring Qualifications

Expert knowledge as well as the experiences and problem solving capability acquired in maintenance sites are important for maintenance work, and hence they are essential for acquiring maintenance qualifications. Applicants, therefore, shall not be able to meet requirements for senior level qualifications until they accumulate a certain amount of experience at each level of qualification. Tables 6-7-11 to 6-7-13 show requirements for the each qualification above.

1) Chief maintenance engineer

Table 6-7-11 Qualification requirements for the chief maintenance engineer

Career	Academic career	Work experience
Person with the qualification of AFC competent maintenance engineer	University graduate of a telecommunications-related technical course	2 years
	Person other than the above and accepted as having expert knowledge similar to the above	3 years

2) Competent maintenance engineer

Table 6-7-12 Qualification requirements for the competent maintenance engineer

Career	Academic career	Work experience
Person with the qualification of AFC maintenance engineer	University graduate of a telecommunications-related technical course	3 years
	Person other than the above and accepted as having expert knowledge similar to the above	5 years

3) Maintenance engineer

Table 6-7-13Qualification requirements for the maintenance engineer

Career/Age	Academic career	Work experience
Person from 18 to 30 years old, regardless of career(*)	University graduate of a telecommunications-related technical course	1 year
	Person other than the above and accepted as having expert knowledge similar to the above	2 years

(*) On the assumption that there is no person with experience because Vietnam introduces AFC systems for the first time.

4. Aptitude Test

   It is required for performing maintenance work to pass a necessary medical aptitude test.

5. Academic examination

   1) Qualification for examination
      a) Person who has passed the aptitude test, and completed pre-examination training,
      b) The general manager of Headquarters (HQ) Electric Signal Communications Department (station equipment) conducts pre-examination training.
   2) Examination coverage
      a) General knowledge on Hanoi Metro
      b) Basic knowledge on the maintenance of electromechanical equipment
      c) Knowledge on rules, procedures, and contact methods for maintenance construction
      d) Knowledge on maintenance construction
      e) Knowledge on various types of equipment for maintenance construction
      f) Knowledge on safety rules and ensuring safety
   3) Judgment criteria

      The passing mark of the academic examination is an accuracy rate of 60% or more.

6. Qualification certificate

   1) Application

      The persons who passed the academic examination shall apply for the certificate to the general manager of Headquarters (HQ) Electric Signal Communications Department (station equipment) with a certification application, a passing certificate of academic examination, and a personal history.
   2) Issue

      The general manager of Headquarters (HQ) Electric Signal communications Department (station equipment) shall review the application and the examination results on the basis of documents, and issue a certificate after qualification is confirmed.
   3) Scope of application

      The certificate is applicable to the maintenance construction of Hanoi Metro’s AFC equipment.

4) Period of validity
The period of validity is three years from the date of issue.

5) Qualification renewal
A qualified person who wants to renew his qualification shall apply for certificate renewal after completing the training provided by the general manager of Headquarters (HQ) Electric Signal Communications Department (station equipment) and obtaining a certificate of completing the training.

6) Reissue
   a) In the case of loss, damage, change in description of a certificate, the person concerned shall apply for reissue to the general manager of Headquarters (HQ) Electric Signal Communications Department (station equipment).
   b) If a qualified person could not renew his qualification by the expiration date due to an inevitable cause, the person shall apply for reissue to the general manager of Headquarters (HQ) Electric Signal Communications Department (station equipment) adding a letter of explanation.

7) Revocation of qualifications
When a qualified person has caused a major accident in construction in which the person has been engaged, or has run a risk of a serious accident, the general manager of Headquarters (HQ) Electric Signal Communications Department (station equipment) may revoke the certificate issued to the concerned person.

8) Expiration of qualifications
When the period of validity of a certificate expires, the concerned certificate becomes invalid.

7. Special Measures

1) Technical certification at the time of the incorporation of Hanoi Metro
It is the first time for Vietnam to introduce an AFC system into the country. At the time of the incorporation of Hanoi Metro, there is no one who has experienced the work described in qualification requirements for technical staff. We therefore take special measures to qualify the staff in charge of AFC maintenance construction for Line 2A that starts business first when they finish training in China and OJT training on Line 2A equipment. On the other hand, we shall carry out an academic examination and an aptitude test to prove that the staff members are technically qualified to perform their duties.

2) Specially appointed technical advisor

In the initial stage of introducing an AFC system and starting business, technical specialists from supporting countries need to instruct and advise the staff as a technical advisor. In such cases, the general manager of Headquarters (HQ) Electric Signal Communications Department (station equipment) may define the scope of duties and authority of the advisors concerned, certify them as specially appointed advisors, and have them perform their duties.

7. Maintenance Management System

To effectively carry out AFC equipment maintenance, we establish a management system based on the knowledge of the maintenance engineering described in the previous chapter. We develop a state monitoring system that facilitates effective maintenance. The system specifically monitors the conditions of equipment such as operating status, deteriorating status, etc. Table 6-7-14 shows the maintenance management system. Equipment diagnosis means the work to collect and analyze data required for state monitoring. Maintenance I and Maintenance II conduct preventive maintenance work to inspect equipment status and carry out necessary adjustment and parts replacement. Maintenance III conducts corrective maintenance to repair failures. Maintenance IV is the work to improve equipment functions to extend its life.

Table 6-7-14 Maintenance management system

Work classification	Explanation
Equipment diagnosis	Collecting and analyzing various data on equipment conditions to normalize and improve maintenance.
Maintenance I	Preventive maintenance to check and adjust functions without disassembling equipment when maintenance is needed.
Maintenance II	Corrective maintenance to conduct function check, parts replacement, and adjustment by disassembling equipment based on a specified method when maintenance is needed.
Maintenance III	Corrective maintenance performed when equipment failure or trouble occurs.
Maintenance IV	Maintenance conducted to improve the reliability, maintainability, and functions of equipment.

8. AFC Equipment Maintenance Rules

(1) We establish equipment-wise maintenance construction criteria for major AFC equipment based on the maintenance management system (Table 6-7-14). The table （Table 6-7-15） is an example of such a system. Various AFC systems exist because of technical development and different system structures. We must therefore establish

rules for AFC equipment by type and function. We must also specify equipment to be managed taking account of the pieces of equipment constituting an AFC system. In the case of Hanoi Metro, we need to know the details of the AFC equipment installed for Line 2A, the first line to start business, and establish the rules in accordance with the equipment.

(2) The equipment-wise construction details mentioned in the previous paragraph shall be specified in accordance with the "equipment-wise maintenance standards" provided separately, and construction shall be carried out based on the standards.

Table 6-7-15 Equipment-wise maintenance construction criteria (form example)

Maintenance type		Equipment name	Type/Function
I	II		
✓	✓	Automatic ticket gate	Specialized ticket gate/Model EGI-1/Manufacturer N
✓	✓	Automatic ticket gate	Specialized ticket collection machine/Model EGC-1/Manufacturer N
✓	✓	Automatic ticket gate	Ticket checking and collection machine/Model EGB-1/Manufacturer N
✓	✓	Automatic ticket gate	Wide ticket checking and collection machine/Model EGWB-1/Manufacturer N
✓	✓	Automatic ticket gate	Specialized ticket gate/Model EGI-1/Manufacturer O
✓	✓	Automatic ticket gate	Specialized ticket collection machine/Model EGC-1/Manufacturer O
✓	✓	Automatic ticket gate	Ticket checking and collection machine/Model EGB-1/Manufacturer O
✓	✓	Operator terminal	Function integrated machine/Model TOMA/Manufacturer T
✓	✓	Automatic add value machine	Coin and bill acceptor/Model AVMM/Manufacturer T
✓		Station server	Manufacturer H

(3) Structural Example of Equipment-wise Maintenance Standards (Automatic Ticket Gate/Model EGI-1/Manufacturer N)

1) Scope of application

Applicable to Specialized Automatic Ticket Gate/Model EG-1/Manufacturer N.

2) Definition of Terms

a) Device

The device means a component classified for each major part and each block.

b) Part

The part means an inspection location classified for each equipment.

c) Maintenance point

The maintenance point means a major inspection point expressed by part name.

The coverage of an inspection point may change depending on the accumulated number of inspection.

d) Maintenance interval

The maintenance interval means an interval at which periodic maintenance is performed.

e) Maintenance item

The maintenance item means an individual checking or adjustment work item.

f) Maintenance method

The maintenance method means a construction method for each maintenance point.

i. Visual check/confirmation work

Check of the appearances, conditions, and operating conditions of equipment visually or by touch.

ii. Confirmation work

Confirmation of operating conditions and adjusted values of equipment.

iii. Confirmation or adjustment

Checking operating conditions and adjusted values, and carrying out readjustment of equipment misadjusted or using wrong adjustment criteria.

iv. Cleaning and confirmation

Cleaning of contamination and check of conditions.

v. Replacement and adjustment

Periodic parts replacement and adjustment.

vi. Confirmation test

A test conducted operating equipment in the maintenance mode (if this mode exists). Adjustment is carried out if trouble is found.

g) Important item

An important inspection point where maintenance such as adjustment is conducted with special care.

h) Criterion value

A criterion value for adjustment

i) Procedure

A detailed description of an adjustment method and work such as lubrication.

3) How to conduct maintenance

a) Inspection and adjustment shall basically be conducted according to the maintenance manual of the model concerned.

b) When trouble is found through confirmation work, adjustment or parts replacement shall be performed.

c) Construction shall be carried out in accordance with a construction procedure document prepared following the form shown in Table 6-7-16

4) Handling of replacement parts

a) When equipment is severely deteriorated or adjustment is difficult, conduct parts replacement.

b) If parts replacement cannot be judged at the time of inspection, describe it in a report, and conduct it after obtaining the approval of the AFC competent engineer and the AFC chief engineer.

c) When the replacement of a major component bearing an important function of equipment such as a block or a unit, prepare a report and carry it out after obtaining the approval of the AFC competent engineer and the AFC chief engineer except in an emergency.

5) Report

a) Make a format of maintenance construction reports to include all reporting items.

b) Prepare a report immediately after the completion of construction, and submit it to the AFC competent engineer and the AFC chief engineer. The AFC chief engineer shall properly record and store the data to make them available for technical management, and report them to Headquarters (HQ) Electric Signal Communications Department.

Table 6-7-16 Equipment-wise maintenance construction procedure document (form example)

Note: The descriptions in the table are for the explanation of the form only. Determine the contents corresponding to the specific equipment used.

Maintenance type	Device name	Type/Function
Maintenance I	Automatic ticket gate	Specialized ticket gate/Model EGI-1/Manufacturer N

Device		Part		Maintenance point		Maintenance interval	Maintenance item	Maintenance method	Important item	Criterion value	Procedure and remarks
01	User interface	01	Operation/display part	01	Guide display LCD		Check display	Cleaning and confirmation			
				02	LCD Backlight		Check display	Cleaning and confirmation			
				03	Passing indicator light		Check display	Cleaning and confirmation			
		02	Door part	01	Door unit		Check operation	Confirmation work		Tightening torque	No backlash Check tightening torque
				02	Door flap		Check operation/ loose/crack	Confirmation work	○		
				03	Door axis cover		Off-position, loose	Confirmation work	○		Undamaged
				04	Flap cover		Off-position, loose, installed condition	Confirmation work	○		Undamaged
		03	Human detection part	01	Transmission type sensor		Contamination, check	Cleaning and confirmation	○		Removing the cover and cleaning
				02	Reflection type sensor		Contamination, check	Cleaning and confirmation	○		Removing the cover and cleaning
02											

Appendix 8-6-7-1-F (A) Requirements for Staff of AFC Related Divisions

With reference to descriptions presented here, the requirements should be occasionally changed in line with actual conditions of equipment and maintenance methods planned for the 2A Line.

Division		Job Category	Main Job Duty	Academic Qualifications	Age	Health Conditions	Experiences	Requirements for New Staff prior to Training	Educational Goals of New Staff
HQ	Equipment division	Manager in charge of AFC operation and management 2 persons	Supervise overall operation and management related to the AFC equipment of the whole HMC. In cooperation with OU, make and implement plans for equipment maintenance, replacement and introduction, for budget and personnel, and other business matters. Make and implement policies to reduce equipment failures and improve its reliability. Implement countermeasures in case of an outbreak of a serious trouble that has a wider influence.	Preferably graduates from universities or schools of the same level who have learnt technical knowledge concerning information processing, electrical/electronic engineering, and mechanical engineering.	Preferably 35 years old or younger, since their work will be mainly related to the new fields to them.	In good condition physically and mentally. Without medical history of mental illness and chromatic discrimination.	Preferential treatment given to those who have experiences in operation and management of communications/electrical/computer systems in the railway sector or the traffic sector, or in sectors related to infrastructures.	New staff should have knowledge about information processing and computers systems at a level enough to understand an outline of the AFC system and its maintenance. In order to carry out job duty, it is required to have not only knowledge about technology but also wider knowledge and management skills, ability to think flexibly, motivation to absorb new knowledge, ability to steadily carry out work, and cooperativeness for carrying out work in collaboration with other divisions. Because it is often difficult to obtain information about AFC in Vietnamese, it is desirable to have English ability at a level enough to read technical documents in English.	New staff should understand technical details of the AFC equipment to be introduced and installed. They should understand the AFC equipment used in stations or the Line Center (LC) and its operation work. They should understand overall knowledge about maintenance methods of equipment to be introduced and installed. They should learn about business planning including personnel, facilities, budgets and other matters required for operation of the AFC equipment used in the whole HMC as well as policies to formulate work rules needed for operation.
OU	Station management division	AFC center manager 4 persons	Work for providing business services for passengers such as ticket management, but not work in divisions related to maintenance.						
	Signaling/ communications division	AFC equipment manager 1 person	Assume responsibility for comprehensive management related to the AFC equipment management, including the following items. Formulate a yearly work plan and prepare a personnel system needed for implementation. Establish work rules, workflows, and work manuals needed for operation and maintenance. Also, supervise whether maintenance work is properly conducted. Collect and organize statistical data concerning equipment maintenance in cooperation with AFC maintenance managers to improve equipment and maintenance work.	Preferably graduates from universities or schools of the same level who have learnt technical knowledge concerning information processing, electrical/electronic engineering, and mechanical engineering.	Preferably 35 years old or younger, since their work will be mainly related to the new fields to them.	In good condition physically and mentally. Without medical history of mental illness and chromatic discrimination.	Preferential treatment given to those who have experiences in SE or maintenance work of communications /electrical/computer systems in the railway sector or the traffic sector, or in sectors related to infrastructures.	New staff should have knowledge enough to understand in details the contents of information processing, electric/electronic technologies, and computer systems that constitute the AFC system. In order to carry out job duty, it is required to have not only knowledge about technology but also wider knowledge and management skills, ability to think flexibly, motivation to absorb new knowledge, ability to steadily carry out work, and cooperativeness for carrying out work in collaboration with other divisions. Because it is often difficult to obtain information about AFC in Vietnamese, it is desirable to have English ability at a level enough to read technical documents in English.	New staff should understand technical details of the AFC equipment to be introduced and installed. They should understand the AFC equipment used in stations or the Line Center (LC) and its operation work. New staff should learn about knowledge needed for supervising the establishment of maintenance rules and manuals of equipment to be introduced and installed. They should learn data analysis methods related to equipment maintenance and related statistical processing methods. They should learn methods of making yearly work plans, covering maintenance of the AFC equipment of the whole OU which they will be in charge of, development of specifications and introduction of new equipment, as well as equipment replacement plans and budget planning.
	Signaling/communications inspection and repair center	AFC maintenance manager 1 person	Person responsible for maintenance technology: Take overall responsibility for continuation of normal and safe operation of the AFC equipment and introduction and installation of equipment.	Preferably graduates from universities or schools of the same level who have learnt technical knowledge concerning information processing, electrical/electronic engineering, and mechanical engineering.	Preferably 35 years old or younger, since their work will be mainly related to the new fields to them.	In good condition physically and mentally. Without medical history of mental illness and chromatic discrimination.	Preferential treatment given to those who have experiences in SE or maintenance work of communications /electrical/computer systems in the railway sector or the traffic sector, or in sectors related to infrastructures.	New staff should have knowledge enough to understand in details the contents of information processing, electric/electronic technologies, and computer systems that constitute the AFC system. In order to carry out job duty, it is required to have not only knowledge about technology but also wider knowledge and management skills, ability to think flexibly, motivation to absorb new knowledge, ability to steadily carry out work, and cooperativeness for carrying out work in collaboration with other divisions.	New staff should understand the contents of technical material concerning the AFC equipment to be introduced and installed. They should understand the AFC equipment used in stations or the Line Center (LC) and its operation work. New staff should learn about knowledge needed for supervising the establishment of maintenance rules and manuals of equipment to be introduced and installed. They should obtain qualifications, if any, needed for implementing maintenance work of the AFC equipment of the whole OU which they will be in charge of. (e.g., qualifications on safety and health-related work, electric work, communication line-related work, information processing technology, and handling of hazardous materials) They should master skills needed for inspection/check, maintenance, and repair of equipment. They should master skills related to measuring technique, numerical analysis, statistical processing, etc. They should master OA skills necessary for making reports and work to accumulate and analyze data.
		Maintenance worker 18 persons	Leader: a leader of workers Take responsibility for maintenance of the AFC equipment and implementation of installation and replacement of equipment according to rules and manuals concerning maintenance work and instructions from the AFC maintenance manager. Supervise work as a leader to assure proper execution while being engaged in work himself. Also get involved in work as a field manager, preparing work reports concerning maintenance work and reporting to the AFC maintenance manager.	Graduates from schools where technical knowledge of information processing, electric/ electronic or mechanical engineering can be learnt. Preferential treatment given to those with a high educational background, such as university graduates, because a high level of technical knowledge is needed for maintenance work.	Preferably 35 years old or younger, since their work will be mainly related to the new fields to them.	In good condition physically and mentally. Without medical history of mental illness and chromatic discrimination.	Preferential treatment given to those who have experiences in SE or maintenance work of communications /electrical/computer systems in the railway sector or the traffic sector, or in sectors related to infrastructures.	New staff should have knowledge about information processing, electric/electronic engineering, and computer devices at a level enough to understand the AFC system maintenance technology. In order to carry out job duty, they need to have not only technical knowledge but also elaborateness and leadership ability to lead a work team and accomplish work following the right procedures and plans.	New staff should understand technical material concerning the AFC equipment to be introduced and installed. They should understand the AFC equipment used in stations or the Line Center (LC) and its operation work. They should obtain qualifications, if any, needed for implementing maintenance work of the AFC equipment of the whole OU which they will be in charge of. (e.g., qualifications on safety and health-related work, electric work, communication line-related work, information processing technology, and handling of hazardous materials) They should master skills needed for inspection/check, maintenance, and repair of equipment. They should master skills related to measuring technique, numerical analysis, statistical processing, etc. They should master OA skills necessary for making reports and work to accumulate and analyze data.
			Worker: In charge of the AFC equipment maintenance, installation, and replacement subject to rules and manuals concerning maintenance work and instructions from the leader.	Graduates from schools where technical knowledge of information processing, electric/ electronic or mechanical engineering can be learnt. Preferential treatment given to those with a high educational background,	Preferably 35 years old or younger, since their work will be mainly related to the new fields to them.	In good condition physically and mentally. Without medical history of mental illness and chromatic discrimination.	Preferential treatment given to those who have experiences in SE or maintenance work of communications /electrical/computer systems in the railway sector or the traffic sector, or in sectors	New staff should have knowledge about information processing, electric/electronic engineering, and computer devices at a level enough to understand drawings, specifications, and manuals related to the AFC system maintenance work. In order to carry out job duty, they need to have not only technical knowledge but also elaborateness and serious natures to accomplish work following the right procedures and plans.	New staff should understand the AFC equipment used in stations or the Line Center (LC) and its operation work. They should learn about structure of the AFC equipment which they will be in charge of, instruction manuals, and maintenance manuals. They should obtain qualifications, if any, needed for implementing maintenance work of the AFC equipment of the whole OU which they will be in charge of. (e.g., qualifications on safety and health-related work, electric work, communication line-related work, information processing technology, and handling of hazardous materials)

Appendix 8-6-7-2-A(A) Number of Staff Required for AFC Equipment Maintenance Work

1. General

Hanoi Metro consists of Headquarters Group (HQ) and Group responsible for passenger transportation work (OU). They have their own organizations with respective functions for AFC equipment maintenance as shown in Figure 6-7-13. They need to secure the number of staff required for these functions.

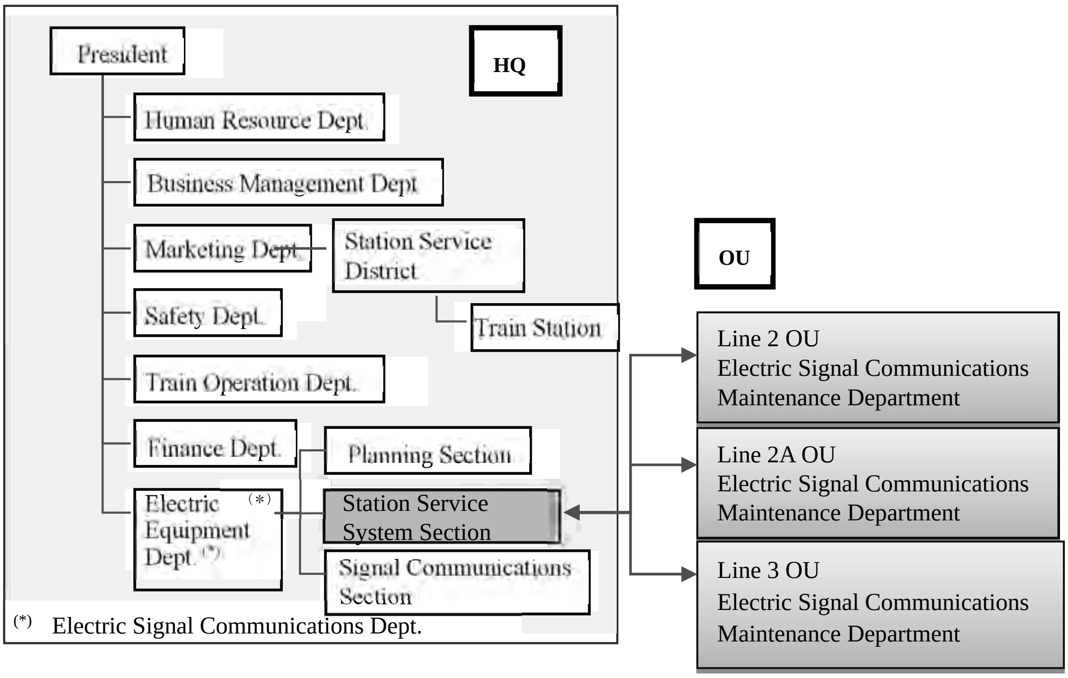


Fig. 6-7-13 Roles of relevant groups in maintenance construction

2. Headquarters (HQ)

In Headquarters, the Station Service system Section is mainly responsible for the planning and management of AFC equipment maintenance. Its duties are as follows:

(1) Items on approvals and licenses from authorities relevant to the work concerned
(2) Items on construction contracts and construction entrustment/commitment contracts relevant to the work concerned
(3) Items on the demand and supply of necessary materials
(4) Items on the prevention, investigation, and reporting of accidents relevant to the work concerned
(5) Items on the management of the maintenance of station service system equipment
(6) Items on the survey, planning, design, and construction of station system equipment for new installation and improvement

To perform these roles, Hanoi Metro shall have the organizational structure shown in Figure 6-7-14. At the time of the business start of Line 2A, however, Hanoi Metro operates only one line, and the scales of 12 stations and the AFC system are small. It is therefore sufficient to assign one person for the above work instead of setting up a section. The same applies to the planning work, where a person in charge of planning and a person in charge of the AFC system cooperate with each other to perform their duties. As the number of operating lines increases and the AFC system scale becomes larger, the number of staff is increased.

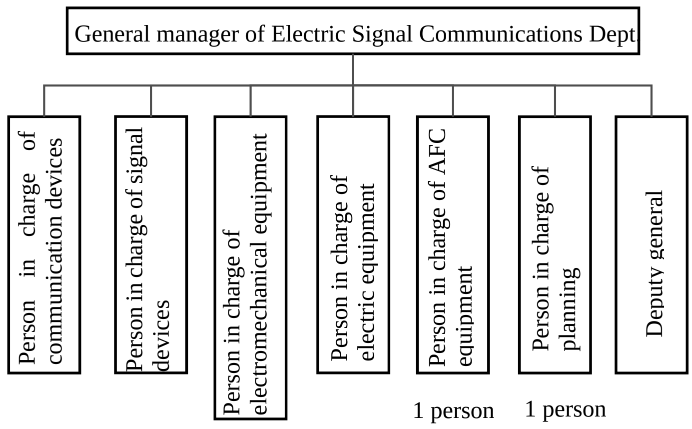


Fig. 6-7-14 AFC maintenance organization and staff allocation at the headquarter

3. Passenger Transportation Group (OU)

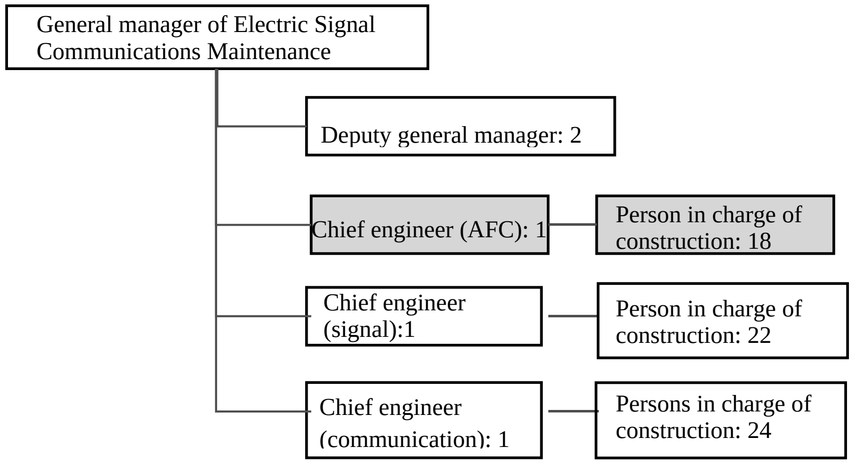
(1) AFC equipment group in Passenger Transportation Group establishes Electric Signal Communications Maintenance Department with the major roles of maintaining and improving the functions of AFC equipment installed in the points of use such as train stations. It has the following duties:

1) Items on maintenance construction management work
2) Items on maintenance construction work
3) Items on outsourcing contracts
4) Items on equipment lease contract
5) Items on On-Call >>> Whether the control office deals with it. (To be discussed)

To perform these roles, the Department has the organizational structure shown in Figure 6-7-15. The number of staff described here is that needed to handle Line 2A only, and the number needs to be increased as the number of lines increases.

(2) The chief engineer (AFC) in the figure mainly carries out maintenance construction management and contract work under the instructions of the deputy general manager, and manages, supervises, and instructs the team in charge of construction.

(3) The person in charge of construction in the figure performs maintenance construction at the point of use of equipment or in a maintenance factory. As explained in the previous chapter, the maintenance of AFC equipment must be carried out on a 24-hour basis. The work system, however, must be structured in accordance with the rules stipulated in the Labor Law (10/2012/QH13).



*Each number indicates the number of persons in charge

Fig. 6-7-15 Organizational structure of Electric Signal Communications Maintenance Department

(4) Rules on work hours stipulated in the Labor Law
The law specifies labor hours, overtime work hours, midnight shift, and paid time off in detail as follows:

1) Ordinary work hours shall not exceed 8 hours a day and 48 hours a week. Work not exceeding 10 hours a day is, however, allowed if work hours a week do not exceed 48 hours.
2) The midnight shift is defined as any shift with a scheduled starting time on and after 22:00 and before 07:00 the next day.
3) The overtime work shall not exceed the 50% of work hours of a day. The overtime work hours shall not exceed 12 hours a day, 30 hours a month, and 200 hours a year.

4) When working for 8 hours or continuously working for 6 hours, the worker shall be allowed at least a 30 minute paid break. In the case of the midnight shift, the worker shall be allowed a 45 minute paid break.
5) The worker engaged in shift work shall be allowed a 12 hour break before starting the next work.
6) A worker shall be allowed at least a 24 hour continuous break a week. If a worker cannot have weekly time off due to a work system, the worker shall be entitled to have 4 days of time off a month.
7) If a worker works for the same employer for a year, the person shall be entitled to have 12 days of paid time off.
8) Besides the above, workers may take the national holidays specified in the Labor Law as a paid time off.

(5) Study on the work system of persons in charge of construction

The shift work system known as the four teams and three shifts system enables 24-hour maintenance construction and complies with the rules specified in the Labor Law. Table 6-7-17 shows its example. It consists of four teams from Teams A to D, and sets work hours as shown in the table. The Time columns show the break time each team can take before it starts its respective shift work. The system meets the conditions of a 12 hour break before the start of shit work, a 24 hour continuous break a week, the midnight shift from 22:00 to 07:00 the next day, work for 8 hours or less a day, and 48 hours or less a week.

The actual application of the system needs to the personnel management group specialized in work systems, referring to other laws and regulations including the detailed rules of the Labor Law.

Table 6-7-17 Shift work system (example)

Work hours	Mon		Tue		Wed		Thu		Fri		Sat		Sun	
	Time	Team	Time	Team	Time	Team	Time	Team	Time	Team	Time	Team	Time	Team
6:00-15:00	31	A	15	A	15	A	31	B	15	B	15	B	31	C
14:00-23:00	15	B	15	B	31	C	15	C	15	C	31	D	15	D
22:00-7:00	15	C	55	D	15	D	15	D	55	A	15	A	15	A
Break	D		C		B		A		D		C		B	

(6) Study on the necessary number of staff

1) The four team and three shift system requires four teams.

2) As described in the section on the regulations for AFC maintenance construction, a supervisory person (a chief engineer) needs to be allocated in a construction site. At least one person in each team must be qualified as a competent maintenance engineers. The number of persons in charge of

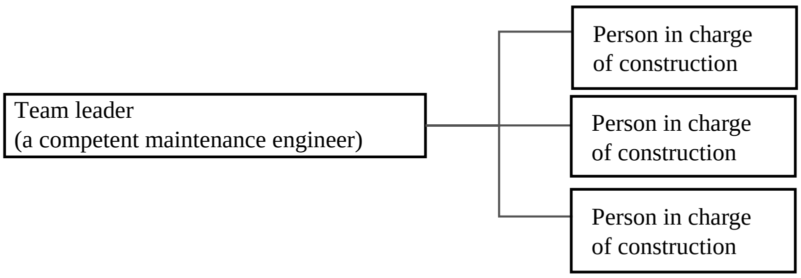


Fig. 6-7-16 Organization of a construction team

construction under the instructions of this supervisory person needs to be two or more from the viewpoints of heavy load carrying work, hazard prevention, and mutual help. Taking account of the sickness absence of one person, the number of persons needed to continue construction work is set to three. Figure 6-7-16 shows the resultant organization of each team. The total number required for four teams is 16.

The above staff allocation cannot ensure proper responses in the events of the sickness absence of two or more persons due to an epidemic of influenza and a vacancy caused by paid time off. It is thus necessary to add team leaders in charge of on-site construction to the system as the staff for preparing and coordinating work plans, managing the preparation of application forms and reports, and responding to the above cases and the occurrence of accidents. In the case of Line 2A, the planned number of staff is 18, and hence the additional number of staff is two.

(7) Study on the validity of the amount of work and the allocated number of staff

The above study was conducted from the viewpoints of organizational functions and labor management in the case of Line 2A. We then need to verify whether this staff allocation enables accomplishing the AFC equipment maintenance work of Line 2A. This study requires clarifying the following items explained in the previous section:

1) Number of train stations
2) Types and number of AFC equipment
3) Maintenance construction criteria for each equipment
4) Maintenance construction procedure and standard construction time for each equipment

Presently (as of November 2013), data for items a) and b) are available from the Line 2A project, but data for items c) and d) lack information on devices and equipment. The latter data must be prepared after they are fixed and become available. We therefore make trial calculations on certain assumptions to show calculation methods using information on Tokyo Metro and other railway operation companies, though different models are used.

1) Number of train stations: 12
2) Types and number of major AFC equipment (from TECHNICAL DESIGN): Table 6-7-18 shows the types and number of major AFC equipment. Automatic gates and automatic ticket vending machines account for the majority of equipment, indicating that maintenance for them constitute the majority of maintenance.

Table 6-7-18 Major AFC equipment of Line 2A

AFC equipment	Station server	Station monitor	Ticket server	Automatic ticket gate	Automatic ticket vending machine	Semi-automatic ticket vending machine	Total
Number of equipment	12	12	12	139	96	24	295

3) Construction criteria must be set based on data such as utilization rates, model-wise failure modes、 and failure rates even for the same type of equipment. Table 6-7-19 lists the general features of each type of AFC equipment, where periodic inspection intervals are just for reference. Ticket gates and automatic ticket vending machines that account for the majority of equipment may need about two months of preventive maintenance interval.

Table 6-7-19 Main inspection points and intervals of AFC equipment

AFC equipment	Main inspection point	Periodic inspection interval for reference（※）
Ticket gate （AG）	Door section Human detection sensor	About 2 months of interval for points with a high failure rate
Ticket vending machine （AVM, ATVM）	Bill processor Mechanical parts such as a card processor	About 2 months of interval for points with a high failure rate
TOM	Bill processor Mechanical parts such as a card processor	About 2 months of interval for points with a high failure rate
Station Controller	Security functions Installation conditions, wiring	About 6 months of interval if installed a proper environment

4) Estimated maintenance construction time is about one hour/equipment in the case of the maintenance of installed equipment (Maintenance I explained in the previous section).

5) On the assumption of the above, the trial calculations below conclude that the present staff plan for Line 2A is valid.

   a) Total number of construction hours is 25 hours/station (25 units x 1 hour).

   b) Construction during business hours is conducted in an undesirable environment and makes operating equipment unusable, causing passengers inconvenience. It is desirable to conduct construction outside business hours as much as possible. Such work system means working eight hours from 22:00 to 07:00 of the next day. Other hours are used for disassembly maintenance and failure repair in the maintenance factory. In the above case, 480 hours can be used for maintenance in two months.

2 months = 480 hours (8 hours x 60 days)

c) The number of stations maintainable during two months is 19 (480 hours ÷ 25 hours), and thus the periodic inspection of Line 2A (number of stations = 12) is workable.

6) From the above result some extra time seems to be available. We only used major equipment for calculation, assuming a maintenance time of 1 hour/equipment, and ignoring the degrees of proficiency of persons in charge. Besides, taking account of the necessity of the emergency call of staff for immediate recovery from accidents and failures, the above calculated number of staff is valid.

Appendix 8-6-7-2-B(A) Maintainable and Practical Maintenance Items in Vietnam

1. General

In Vietnam, Line 2A is the first line to introduce an AFC system to its railway system. Technical accumulation begins from the start of the business of Line 2A. Since the market of AFC equipment has not existed in Vietnam, neither AFC equipment suppliers nor its maintenance companies exist. At the initial stage after the start of business, therefore, the railway company may not be able to handle some technical items. Maintenance is, however, not limited to technical items alone. The types of work in the P, C, and A phases of the PDCA cycle are management, and hence the staff properly completed the education and training such as shown in Table 6-7-20 can carry out the work.

Table 6-7-20 Items that can be handled in the country

PDCA cycle		Work	Implementation in Vietnam
PLAN	Planning	Development of maintenance plans	Practicable after completing proper training
DO	Implementation	Implementation of equipment inspection, diagnosis, and maintenance	Detailed study required
CHECK	Recording and analysis	Collection and analysis of maintenance information	Practicable after completing proper training
ACTION	Feedback	Technical management	Practicable after completing proper training

2. Study on Technical Work Items

Technical work items include the equipment diagnosis described in the previous section and construction work from Maintenance I to Maintenance IV. Equipment diagnosis, Maintenance I, and Maintenance II require in-condition or in-factory implementation, and therefore must be carried out in Vietnam; otherwise, the AFC system is inoperable. We need human source development and facilities for this purpose.

On the other hand, Maintenance III (corrective maintenance and failure repair) and Maintenance IV (maintenance for improvement and improvement of equipment functions) include the items that cannot be handle in Vietnam alone depending on the types of work.

(1) Maintenance III (corrective maintenance and failure repair)

1) The case of parts and replaceable units

In the case of replacement of parts and units for restoration, work can be carried out in Vietnam by storing them in the country. Sometimes, however, repairing these parts and units requires advanced failure analysis technology, profound understanding of electronic and mechanical product technologies, and fabrication capability of high-precision parts. In such cases, outsourcing to manufacturers is needed. In some cases, the manufacturers send the parts and units to technical centers outside the country for repair.

2) Failures of the parts that cannot be replaced

In this case, equipment mostly needs to be completely overhauled and restructured. Such repair requires a variety of measurement equipment, parts, materials, and engineers with high-level technology. In many cases, therefore, the manufacturing and technical departments of equipment manufacturers carry out the repair at first.

(2) Maintenance IV (maintenance for improvement and improvement of equipment functions)

1) The case of “Kaizen”

In the case of the improvement known as “Kaizen,” where employees propose and implement improvement on the process of daily work, employees themselves can often carry out improvement, or in many cases improvement can be made using domestic equipment and technology.

2) The case of the improvement of basic functions

In the case of the improvement rooted in the results of technical development such as the improvement of materials, mechanisms, and functions,
the knowledge, experiences, and know-how of equipment and products are mostly required, and hence in many cases only equipment manufacturing companies having such technical skills can handle this kind of work initially.
The planning and proposals for improvement is, however, mostly created in the practical operations of railway business, and therefore, we can expect a great contribution of the Vietnamese side.
Table 6-7-21 summarizes the above. The items that can be handled in Vietnam will increase significantly as technical accumulation increases and human resource development advances in the country.

Table 6-7-21 Study on the feasibility of conducting Maintenance III and IV domestically

Maintenance work		Implementation in Vietnam
Maintenance III (corrective maintenance)	Replacement of parts and units	Mostly possible if parts and units inventory and work manuals exist.
	Parts and units	Mostly impossible because advanced equipment and technology are needed.
	Repair of parts that cannot be replaced	The same as above
Maintenance IV (maintenance for improvement)	“Kaizen”	Mostly possible.
	Improvement of basic functions	Sometimes difficult.

Appendix 8-6-7-2-C(A) Information on Standard Market Prices for Maintenance Items

1. Calculation of Prices for Equipment Maintenance Work
   "Prices" do not only mean the prices for Hanoi Metro's outsourcing work to external companies. In the case where Hanoi Metro directly carries out maintenance construction, "prices" have the same meaning with "construction costs."

2. Cost Structures
   The technical design document for Line 2A (TECHNICAL DESIGN, OCT 2013) lists the appliances, installations, devices, and equipment shown in Table 6-7-22.
   Unit prices for their maintenance are generally composed of the following costs:
   (1) Material costs
   Cost of parts for repair and replacement, unit costs, and utilities costs for electricity, gas, and water used for construction
   (2) Equipment costs (fixed costs)
   Allocated fixed costs for machinery and appliances, measurement equipment, and buildings
   (3) Personnel costs
   Personnel costs for maintenance construction
   (4) Outsourcing costs
   Outsourcing costs in the case of outsourcing part of maintenance to external companies
   (5) Administrative costs
   Allocation costs from indirect groups

Table 6-7-22 Major AFC appliances, installations, and equipment of Line 2A

No.	Location	Appliance, installation, equipment	Number of units
Train station			
1	Station equipment room	Cabinet (including distribution board, mount base)	12
2		Station server	12
3		Emergency warning system	12
4		L3 switch	12
5		Light-metal conversion module	24
6		Work station	12
7		UPS (30KVA)	12
8		Battery storage box (with 0.5 hr power feeding battery)	12
9		Duplex power switch box	12
10		Grounding end box	12
11	Operation control room	Monitoring work station	12
12		Network printer	12
13	Station service room	Ticket work station	12
14		Network printer	12
15		IC card ticket counter	12
16		IC card ticket count, packaging device	12
17		Bill counter	12
18		Coin counter	12
19		IC ticket storage, cash storage box R/W for identifying opening and closing control ID	12
20		IC card ticket storage box (spare)	24
21		Bill storage box (spare)	88
22		IC ticket, bill storage box cabinet	88
23		File cabinet	12
24		Carrying caster	12
25	Station yard	L2 network switch	48
26		Ether I/O controller	24
27		Ticket checking and collection machine	115
28		Wide ticket checking and collection machine	24
29		Suspended information sign	139
30		Automatic ticket vending machine	88
31		Automatic fare adjustment machine	24
32		Ticket window ticket vending machine	24
33		Portable inspection machine	24
34		Bill counter	24
Maintenance work area			
35	Maintenance yard	Work station	3
36		Network printer	3
37		Portable PC	3
38		Portable recording media	3
39		Portable maintenance device	3
40		Maintenance appliance	3
41		Appliance cabinet	3

3. Calculation of Costs

Since material costs depend on contract conditions such as equipment, equipment suppliers, purchase time, and quantity, they can be calculated when these conditions are materialized. Equipment, personnel, and administrative costs can be calculated when organizations, number of staff, and assets are determined. Outsourcing costs can be calculated when its details and conditions such as taxes, transportation charges, and insurance premiums are determined. In the case of abroad, the conditions for CIF (cost, insurance, and freight) prices that include the costs for freight and insurance or FOB (free on board) prices that sellers bear the costs needed until loading cargo on board the ship are also considered in calculation. At the stage of preparing this interim report, these conditions have not been determined. Cost calculation can be made when the company is incorporated and these conditions are set.

4. Outsourcing

(1) Since AFC equipment consists of many advanced electronic devices, outsourcing part of maintenance to external companies with expertise is appropriate as an option.

(2) Outsourcing by model (manufacturer) and by case or project should be avoided, especially in the case of taking emergency measures. The following system should be developed and operated.

1) Outsource all equipment by area (one-stop service).
2) Share standard construction prices under a basic contract and perform construction for an appropriate price.
3) When a case occurs, instruct starting construction, and take rapid measures.

Appendix 8-6-7-2-D(A) Calculation method of the number of AFC equipment maintenance personnel

1. Procedure to calculate the number of the maintenance personnel
   (1) Specify the standard inspection time (*) required for inspection of each machine type.
   (2) Specify the number of the personnel for each unit of work.
   (3) Sum up the maintenance time required in a year for each machine type and each inspection cycle to determine the yearly total maintenance time.
   (4) Specify the yearly scheduled working time per maintenance worker (covering both leaders and workers).
   (5) Determine the total number of the necessary maintenance personnel based on the yearly total maintenance time and the yearly scheduled working time.

*) The standard inspection time means standard working hours necessary for the inspection work that is specified in the maintenance manual.
By adding to this time travel time to a maintenance site, the time needed for maintenance can be obtained.The attached table presents reference values only, so that the specification must be made based on equipment to be actually installed.

2. Example of calculating the number of maintenance workers
   Though this example uses information obtained in terms of AFC equipment used on the 2A Line, it should be reviewed after detailed information is obtained. This material should be used only for learning the calculation method.
   (1) Assumptions of the calculation
      1) The number of units of equipment（Table 6-7-23）

Station No.	Ticket gate	Automatic Ticket Machine	Ticket office machine	Semi-Automatic Ticket Machine	Station controller	Train line server
1	32	12	4	4	1	1
2	12	7	2	2	1	
3	12	7	2	2	1	
4	11	7	2	2	1	
5	12	7	2	2	1	
6	12	6	2	2	1	
7	12	5	2	2	1	
8	12	6	2	2	1	
9	12	6	2	2	1	
10	12	5	2	2	1	
11	12	5	2	2	1	
12	12	7	2	2	1	
Total	163	80	26	26	12	1

      2) The number of yearly working days is set to 290 on the premise of the following days off.
      3) Days off:

a. Non-working days per year: 53

b. Public holidays: 10 days. Since maintenance work should be carried out even on public holidays, shift workers are excluded from the calculation.

c. Paid holidays: 12 days

4) The working hours are set to 8 hours/day.

Travel time is not included in the table. This is because the urban railways have only total length of about 20 km, and travel time has no significant influence on calculation results. However, when formulating a daily maintenance plan, a loss due to travel time must be kept down by avoiding travelling as much as possible.

The standard inspection time varies substantially depending on equipment specifications, skill and proficiency levels of workers and so on. The standard time used here assumes that workers with less experience are in charge.

(2) Formulation of an AFC equipment maintenance plan (Example)

1) Standard inspection time（Table 6-7-24）：Specify standard inspection time for each piece of equipment, and calculate the necessary maintenance time. When determining the standard inspection time, working time of staff concerned should be measured.The time indicated below is an example. With an increase in the proficiency level of a worker, the maintenance work can be completed in a shorter time, and there will be no need for the worker to be always paired with a leader.

Table 6-7-24 Standard inspection time

Equipment	Inspection location	Inspection item	Inspection cycle (months)	Number of yearly inspections	Inspection standard time (min)	Number of units	Required time for yearly inspections (hr.)	Required number of workers (persons)	Required number of leaders (persons)	Yearly required time for workers (hr.)	Yearly required time for leaders (hr.)
Automatic Ticket Gate	The whole	Overall functions	2	6	30	163	489	1	1	489	489
	Exterior	Deformation, damage and corrosion	2	6	10	163	163	1	1	163	163
		State of fixation and installation	2	6	10	163	163	1	1	163	163
		Connection conditions of electrical/communication wirings	2	6	10	163	163	1	1	163	163
	Display unit	Display intensity	2	6	10	163	163	1	1	163	163
		Accumulation of dusts and taint	2	6	15	163	244.5	1	1	244.5	244.5
	Sensor unit	Sensor operation	2	6	10	163	163	1	1	163	163
	Door area	Taint, damage and breakage	2	6	15	163	244.5	1	1	244.5	244.5
		Opening-closing operation	2	6	10	163	163	1	1	163	163
	IC verification unit	IC card detection	2	6	10	163	163	1	1	163	163
	Ticket collection unit	Accumulation of dusts and taint	2	6	15	163	244.5	1	1	244.5	244.5
	Staff operating portion	Switching operation	2	6	10	163	163	1	1	163	163
		Fault detection function	6	2	20	163	108.67	1	1	108.67	108.67
	Power supply unit	Uninterruptible power source	6	2	10	163	54.33	1	1	54.33	54.33
		Range of power supply voltage	6	2	10	163	54.33	1	1	54.33	54.33
		Range of insulation resistance values	12	1	10	163	27.17	1	1	27.17	27.17
	Overhaul	Inspection of door movability and replacement of parts	36	0.33	60	163	54.33	1	1	54.33	54.33
	Battery replacement	UPS battery replacement	36	0.33	30	163	27.17	1	1	27.17	27.17
Automatic Ticket Machine	The whole	Overall functions	2	6	30	80	240	1	1	240	240
	Exterior	Deformation, damage and corrosion	2	6	10	80	80	1	1	80	80
		State of fixation and installation	2	6	10	80	80	1	1	80	80
		Connection conditions of electrical/communication wirings	2	6	10	80	80	1	1	80	80
	Operation panel	Display intensity	2	6	10	80	80	1	1	80	80
		Accumulation of dusts and taint	2	6	15	80	120	1	1	120	120
	Selection button	Button operation	2	6	10	80	80	1	1	80	80
		Accumulation of dusts and taint	2	6	15	80	120	1	1	120	120
	Call button	Button operation	2	6	10	80	80	1	1	80	80
		Accumulation of dusts and taint	2	6	15	80	120	1	1	120	120
	Staff operating portion	Display intensity	2	6	10	80	80	1	1	80	80
		Accumulation of dusts and taint	2	6	15	80	120	1	1	120	120
		Fault detection function	6	2	20	80	53.33	1	1	53.33	53.33
	Recording unit	Printing conditions of the printer	2	6	5	80	40	1	1	40	40
	Bill insertion port	Shutter operation	2	6	10	80	80	1	1	80	80
		Exterior of the feed roller	2	6	10	80	80	1	1	80	80
		Sensor operation	2	6	10	80	80	1	1	80	80
		Bill feeding function	2	6	15	80	120	1	1	120	120
	Bill processing unit	Banknote identification function	2	6	15	80	120	1	1	120	120
		Acceptance rate of bills	2	6	20	80	160	1	1	160	160
		Function to retain bills for change	2	6	10	80	80	1	1	80	80
	Coin slot	Delivery function	2	6	15	80	120	1	1	120	120
		Sensor operation	2	6	10	80	80	1	1	80	80
		Shutter operation	2	6	10	80	80	1	1	80	80
	Coin processing unit	Banknote identification function	2	6	15	80	120	1	1	120	120
		Acceptance rate of coins	2	6	20	80	160	1	1	160	160
		Hopper operation	2	6	10	80	80	1	1	80	80
	IC card processing unit	Card detection function	2	6	10	80	80	1	1	80	80
		Sensor function to detect residual quantity	2	6	10	80	80	1	1	80	80
		Delivery function	2	6	15	80	120	1	1	120	120
		Sensor function to detect a card left	2	6	10	80	80	1	1	80	80
		Sensor function to collect cards	2	6	10	80	80	1	1	80	80
		Sensor function for the collection box	2	6	10	80	80	1	1	80	80
	Power supply unit	Uninterruptible power source function	6	2	10	80	26.67	1	1	26.67	26.67
		Range of power supply voltage	6	2	10	80	26.67	1	1	26.67	26.67
		Range of insulation resistance values	12	1	10	80	13.33	1	1	13.33	13.33
	Coin collection safe	Switch function to set the safe	12	1	10	80	13.33	1	1	13.33	13.33
	Data log	Operation data, counter value, etc.	2	6	15	80	120	1	1	120	120
	Overhaul	Inspection and replacement of bill/coin processing movable parts	36	0.33	60	80	26.67	1	1	26.67	26.67
	Battery replacement	UPS battery replacement	36	0.33	30	80	13.33	1	1	13.33	13.33
Ticket Office Machine	Exterior	Connection conditions of electrical/communication wirings	2	6	10	52	52	1	1	52	52
	Operation display unit	Display intensity	2	6	10	52	52	1	1	52	52
		Accumulation of dusts and taint	2	6	15	52	78	1	1	78	78
	Operation button	Button operation	2	6	10	52	52	1	1	52	52
		Accumulation of dusts and taint	2	6	15	52	78	1	1	78	78
	IC card processing unit	Card detection function	2	6	10	52	52	1	1	52	52
		Sensor function to detect residual quantity	2	6	10	52	52	1	1	52	52
		Delivery function	2	6	15	52	78	1	1	78	78
		Sensor function to detect a card left	2	6	10	52	52	1	1	52	52
		Sensor function to collect cards	2	6	10	52	52	1	1	52	52
		Sensor function for the collection box	2	6	10	52	52	1	1	52	52
	Control unit	Security management function	1	12	15	52	156	1	1	156	156
		Version of operating software	2	6	15	52	78	1	1	78	78
	Printer unit	Printing conditions of the printer	2	6	5	52	26	1	1	26	26
	Cash management machine	Counting function	2	6	15	52	78	1	1	78	78
	Power supply unit	Uninterruptible power source function	6	2	10	52	17.33	1	1	17.33	17.33
		Range of power supply voltage	6	2	10	52	17.33	1	1	17.33	17.33
		Range of insulation resistance values	12	1	10	52	8.67	1	1	8.67	8.67
	Overhaul	Inspection of the card processing unit and replacement of movable parts	36	0.33	60	52	17.33	1	1	17.33	17.33
	Battery replacement	UPS battery replacement	36	0.33	30	52	8.67	1	1	8.67	8.67
Station Controller	The whole	Overall functions	2	6	30	12	36	1	1	36	36
	Operation display unit	Display intensity	2	6	10	12	12	1	1	12	12
		Accumulation of dusts and taint	2	6	15	12	18	1	1	18	18
	Control unit	Security management function	1	12	10	12	24	1	1	24	24
		State of access right setting	1	12	10	12	24	1	1	24	24
		Version of operating software	1	12	10	12	24	1	1	24	24
		Free space	1	12	10	12	24	1	1	24	24
		Data processing capacity	1	12	10	12	24	1	1	24	24
		Data backup	2	6	60	12	72	1	1	72	72
	Power supply unit	Uninterruptible power source	6	2	10	12	4	1	1	4	4
		Range of power supply voltage	6	2	10	12	4	1	1	4	4
		Range of insulation resistance values	12	1	10	12	2	1	1	2	2
	Battery replacement	UPS battery replacement	36	0.33	30	12	2	1	1	2	2
Train Line Server	Security server	Security management function	Continuous monitoring					1	1	8760	8760
	Server	State of access right setting	Continuous monitoring								
		State of the whole	Continuous monitoring								
	Database device & disk array	Data processing capacity	Continuous monitoring								
		Free space	Continuous monitoring								
	Operation terminal	State of access right setting	Continuous monitoring								
		Security management function	2	6	10	1	1	1	1	1	1
	Backup	Data backup	2	6	60	1	6	1	1	6	6
	Server	Backup function	2	6	10	1	1	1	1	1	1
	Software	Version check	2	6	10	1	1	1	1	1	1
	Chassis	Accumulation of dust (in the cooling opening, etc.)	2	6	15	1	1.5	1	1	1.5	1.5
	Power source	Uninterruptible power source	6	2	10	1	0.33	1	1	0.33	0.33
		Range of power supply voltage	6	2	10	1	0.33	1	1	0.33	0.33
		Range of insulation resistance values	12	1	10	1	0.17	1	1	0.17	0.17
	Battery replacement	UPS battery replacement	36	0.33	30	2	0.33	1	1	0.33	0.33
								Required time for inspection work of station equipment (hr.)		7684	7684
								Required time for monitoring of the train line server		8760	8760

2) Time for maintenance work for each location（Table 6-7-25）

- Calculate the time necessary for maintenance work in each location at a station and the Line center based on the standard inspection time.

Table 6-7-25 Required Maintenance Time in Inspection Work for Each Maintenance Location based on Standard Inspection Time*) (Example)

Location	Equipment	Inspection interval	1 month	2 months	6 months	1 year	3 years
		Standard Inspection Time (min): Automatic ticket gate		155	40	10	90
		Standard Inspection Time (min): Automatic Ticket Machine		415	40	20	90
		Standard Inspection Time (min): Ticket office machine	15	160	20	10	90
		Standard Inspection Time (min): Station controller	50	115	20	10	30
		Standard Inspection Time (min): Train line server		105	20	10	30
		Number of units	Standard inspection time for each inspection				
Station 1	Ticket gate	32	0	4960	1280	320	2880
	Automatic Ticket Machine	12	0	4980	480	240	1080
	Ticket office machine	8	120	1280	160	80	720
	Station controller	1	50	115	20	10	30
	Total		2 hours 50 minutes	188 hours 55 minutes	32 hours 20 minutes	10 hours 50 minutes	78 hours 30 minutes
Station 2	Ticket gate	12	0	1860	480	120	1080
	Automatic Ticket Machine	7	0	2905	280	140	630
	Ticket office machine	4	60	640	80	40	360
	Station controller	1	50	115	20	10	30
	Total		1 hour 50 minutes	92 hours 0 minutes	14 hours 20 minutes	5 hours 10 minutes	35 hours 0 minute
Station 3	Ticket gate	12	0	1860	480	120	1080
	Automatic Ticket Machine	7	0	2905	280	140	630
	Ticket office machine	4	60	640	80	40	360
	Station controller	1	50	115	20	10	30
	Total		1 hour 50 minutes	92 hours 0 minute	14 hours 20 minutes	5 hours 10 minutes	35 hours 0 minute
Station 4	Ticket gate	11	0	1705	440	110	990
	Automatic Ticket Machine	7	0	2905	280	140	630
	Ticket office machine	4	60	640	80	40	360
	Station controller	1	50	115	20	10	30
	Total		1 hour 50 minutes	89 hours 25 minutes	13 hours 40 minutes	5 hours 0 minute	33 hours 30 minutes
Station 5	Ticket gate	12	0	1860	480	120	1080
	Automatic Ticket Machine	7	0	2905	280	140	630
	Ticket office machine	4	60	640	80	40	360
	Station controller	1	50	115	20	10	30
	Total		1 hour 50 minutes	92 hours 0 minutes	14 hours 20 minutes	5 hours 10 minutes	35 hours 0 minute
Station 6	Ticket gate	12	0	1860	480	120	1080
	Automatic Ticket Machine	6	0	2490	240	120	540
	Ticket office machine	4	60	640	80	40	360
	Station controller	1	50	115	20	10	30
	Total		1 hour 50 minutes	85 hours 5 minutes	13 hours 40 minutes	4 hours 50 minutes	33 hours 30 minutes
Station 7	Ticket gate	12	0	1860	480	120	1080
	Automatic Ticket Machine	5	0	2075	200	100	450
	Ticket office machine	4	60	640	80	40	360
	Station controller	1	50	115	20	10	30
	Total		1 hour 50 minutes	78 hours 10 minutes	13 hours 0 minute	4 hours 30 minutes	32 hours 0 minute
Station 8	Ticket gate	12	0	1860	480	120	1080
	Automatic Ticket Machine	6	0	2490	240	120	540
	Ticket office machine	4	60	640	80	40	360
	Station controller	1	50	115	20	10	30
	Total		1 hour 50 minutes	85 hours 5 minutes	13 hours 40 minutes	4 hours 50 minutes	33 hours 30 minutes
Station 9	Ticket gate	12	0	1860	480	120	1080
	Automatic Ticket Machine	6	0	2490	240	120	540
	Ticket office machine	4	60	640	80	40	360
	Station controller	1	50	115	20	10	30
	Total		1 hour 50 minutes	85 hours 5 minutes	13 hours 40 minutes	4 hours 50 minutes	33 hours 30 minutes
Station 10	Ticket gate	12	0	1860	480	120	1080
	Automatic Ticket Machine	5	0	2075	200	100	450
	Ticket office machine	4	60	640	80	40	360
	Station controller	1	50	115	20	10	30
	Total		1 hour 50 minutes	78 hours 10 minutes	13 hours 0 minutes	4 hours 30 minutes	32 hours 0 minute
Station 11	Ticket gate	12	0	1860	480	120	1080
	Automatic Ticket Machine	5	0	2075	200	100	450
	Ticket office machine	4	60	640	80	40	360
	Station controller	1	50	115	20	10	30
	Total		1 hour 50 minutes	78 hours 10 minutes	13 hours 0 minutes	4 hours 30 minutes	32 hours 0 minute
Station 12	Ticket gate	12	0	1860	480	120	1080
	Automatic Ticket Machine	7	0	2905	280	140	630
	Ticket office machine	4	60	640	80	40	360
	Station controller	1	50	115	20	10	30
	Total		1 hour 50 minutes	92 hours 0 minute	14 hours 20 minutes	5 hours 10 minutes	35 hours 0 minute
Line Center	Train line server	1	0	105	20	10	30
	Total		0 hour 0 minute	1 hour 45 minutes	0 hour 20 minutes	0 hour 10 minutes	0 hour 30 minutes
Total inspection time (for each unit of work and each work division)			23 hours 0 minute	1137 hours 50 minutes	183 hours 40 minutes	64 hours 40 minutes	449 hours 0 minutes
Number of yearly inspections			12	6	2	1	0.33
Total inspection time (for each unit of work and each work division)			276 hours 0 minute	6827 hours 0 minute	367 hours 20 minutes	64 hours 40 minutes	149 hours 40 minutes

3) Yearly working time of workers

- Establish a work system for maintenance workers and decide the yearly working time for each worker.
- The following table is an example where a system of 3 shifts with 4 teams is adopted to make the maintenance work possible for 24 hours a day.
- It is necessary to monitor the train line server continuously for 24 hours a day, 365 days a year. Because expertise in the server is also necessary, a group of personnel in charge of the maintenance of station facilities is considered separately.
- If a work system is decided, the yearly working time can be calculated.

Table 6-7-26 Manpower calculation in the AFC maintenance division in a system of 3 shifts with 4 teams (Example)

A case where the number of the OU maintenance workers on the 2A Line is assumed to be 18.

Time Schedule		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Number of days off
		Mon.	Tue.	Wed.	Thu.	Fri.	Sat.	Sun.	Mon.	Tue.	Wed.	Thu.	Fri.	Sat.	Sun.	Mon.	Tue.	Wed.	Thu.	Fri.	Sat.	Sun.	Mon.	Tue.	Wed.	Thu.	Fri.	Sat.	Sun.	Mon.	Tue.	Wed.	
Maintenance Manager		D	D	D	D	D	D	O	D	D	D	D	D	D	O	D	D	D	D	D	D	O	D	D	D	D	D	D	O	D	D	D	4
Work in Track Maintenance Base	Leader 1	D	D	D	D	D	D	O	D	D	D	D	D	D	O	D	D	D	D	D	D	O	D	D	D	D	D	D	O	D	D	D	4
	Worker 1	D	D	D	D	D	D	O	D	D	D	D	D	D	O	D	D	D	D	D	D	O	D	D	D	D	D	D	O	D	D	D	4
Inspection of Station Facilities	Leader 2	A	A	A	O	C	C	C	O	B	B	B	O	A	A	A	O	C	C	C	O	B	B	B	O	A	A	A	O	C	C	C	7
	Leader 3	B	B	O	A	A	A	O	C	C	C	O	B	B	B	O	A	A	A	O	C	C	C	O	B	B	B	O	A	A	A	O	8
	Leader 4	C	O	B	B	B	O	A	A	A	O	C	C	C	O	B	B	B	O	A	A	A	O	C	C	C	O	B	B	B	O	A	8
	Leader 5	O	C	C	C	O	B	B	B	O	A	A	A	O	C	C	C	O	B	B	B	O	A	A	A	O	C	C	C	O	B	B	8
Inspection of Station Facilities	Worker 2	A	A	A	O	C	C	C	O	B	B	B	O	A	A	A	O	C	C	C	O	B	B	B	O	A	A	A	O	C	C	C	7
	Worker 3	B	B	O	A	A	A	O	C	C	C	O	B	B	B	O	A	A	A	O	C	C	C	O	B	B	B	O	A	A	A	O	8
	Worker 4	C	O	B	B	B	O	A	A	A	O	C	C	C	O	B	B	B	O	A	A	A	O	C	C	C	O	B	B	B	O	A	8
	Worker 5	O	C	C	C	O	B	B	B	O	A	A	A	O	C	C	C	O	B	B	B	O	A	A	A	O	C	C	C	O	B	B	8
Monitoring of Train Line Server	Worker 6	A	A	A	O	C	C	C	O	B	B	B	O	A	A	A	O	C	C	C	O	B	B	B	O	A	A	A	O	C	C	C	7
	Worker 7	B	B	O	A	A	A	O	C	C	C	O	B	B	B	O	A	A	A	O	C	C	C	O	B	B	B	O	A	A	A	O	8
	Worker 8	C	O	B	B	B	O	A	A	A	O	C	C	C	O	B	B	B	O	A	A	A	O	C	C	C	O	B	B	B	O	A	8
	Worker 9	O	C	C	C	O	B	B	B	O	A	A	A	O	C	C	C	O	B	B	B	O	A	A	A	O	C	C	C	O	B	B	8
Monitoring of Train Line Server	Worker 6	A	A	A	O	C	C	C	O	B	B	B	O	A	A	A	O	C	C	C	O	B	B	B	O	A	A	A	O	C	C	C	7
	Worker 7	B	B	O	A	A	A	O	C	C	C	O	B	B	B	O	A	A	A	O	C	C	C	O	B	B	B	O	A	A	A	O	8
	Worker 8	C	O	B	B	B	O	A	A	A	O	C	C	C	O	B	B	B	O	A	A	A	O	C	C	C	O	B	B	B	O	A	8
	Worker 9	O	C	C	C	O	B	B	B	O	A	A	A	O	C	C	C	O	B	B	B	O	A	A	A	O	C	C	C	O	B	B	8
																																Total	124
																																Average number of days per person per month	7.75

Category	Number of days off	Number of yearly working days	Yearly working time (the number of working days x 8 hours)
Regular Workers	74	291	2328
Shift Workers	105	260	2080

Scheduled Working Time	8	Hours/day	
Weekly Working Time	48	Hours/week	
Number of Holidays	10	Days/year	In Vietnam, shift workers are excluded.
Days per Year	365	Days/year	
Paid Holidays	12	Days/year	
Regular Work	D	8:00－17:00	
Early Shift Work	A	6:00－15:00	
Late Shift Work	B	14:00－23:00	
Late-Night Shift Work	C	22:00－7:00	

4) Number of maintenance personnel

- The necessary number of personnel to be engaged in maintenance work is determined based on the total standard inspection time needed for maintenance work and yearly working time of workers.
- For vacancies due to accidents, failures, illness of workers, or paid holidays, two staff members in charge of technical management, repair, etc. in the maintenance division should respond to the situation in a "day work (8:00-17:00)" system at a maintenance base.
- The total number of maintenance personnel is 18 with workers (including leaders) for inspection and monitoring and two day-work staff members, as shown in the Table below.

Table 6-7-27 Number of maintenance personnel

Category		Required working time (hr.)	Yearly working time (hr)	Yearly required number of the personnel
Inspection of Station Facilities	Leader	7684	2080	4
	Worker	7684	2080	4
Monitoring of Train Line Server	Leader	8760	2080	4
	Worker	8760	2080	4

Appendix 8-6-7-3-A(A) Acquisition of Planning Methods for Equipment Renewal

1. Rules for the Durable Years of Equipment

(1) Basic Concept of Durable Years

Equipment ages with time and the amount of use after starting operation, and eventually becomes impossible to meet the purpose of its use, and finally reaches the end of life. This period is called life or durable years. IEC 60050 uses the term "Useful Life" and defines it as "under given conditions, the time interval beginning at a given instant of time, and ending when the failure intensity becomes unacceptable or when the item is considered unrepairable as a result of a fault."

The unacceptable failure intensity means the failure intensity with a repair cost increased to an uneconomic level. Software does not wear out, but the time point when it cannot meet required functions is the end of its life. As shown in Figure 6-7-17, two types of life exist: life due to deterioration, and life due to obsolescence because of increase in required functions.

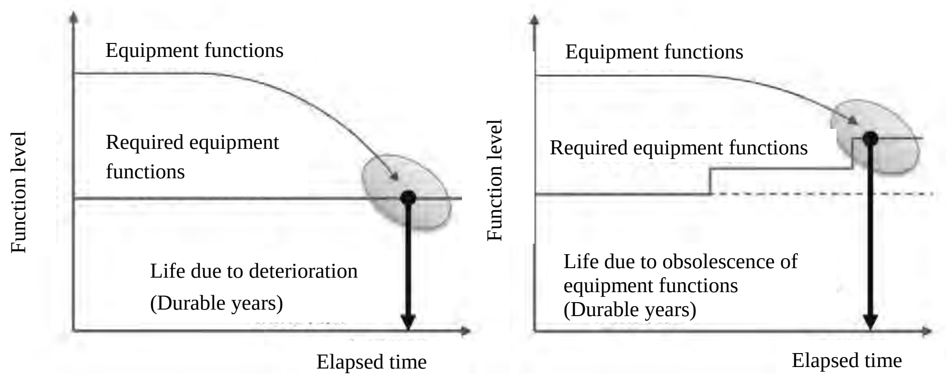


Fig. 6-7-17 Factors determining life (durable years)

(2) Deterioration and Life (Durable Years)

Equipment consisting of one part or unit, or that whose parts and units have the same life has to be disposed of when it reaches the end of life. AFC equipment, however, consists of many parts and units with different deterioration life. Replacing the parts constituting equipment to extend its life as a whole is therefore economically meaningful.

As the deterioration of parts and units increases and the necessity of their repair increases, repair costs also increase. We therefore need to compare the costs required for repair with those for renewal to new equipment, making an advantageous choice from the viewpoint of life cycle costs. The failure modes of major parts and units shown in Table 6-7-3 are important in making the judgment.

(3) Obsolescence and Life

When existing equipment becomes impossible to meet the increased levels of functions required by its user, it becomes obsolete and reaches the end of its life. Quantitatively predicting the tendency of increasing level of requirements is difficult due to unpredictable change in social environment. The tendency, however, has a significant effect on the life of many electronic circuit products used in AFC equipment mentioned blow.

(4) Life Defined in Public Accounting Law/Accounting Standards

Assets of 30 million VND or more are defined as fixed assets by the Vietnamese Accounting Law (03/2003/QH 11) and the Accounting Standards (45/2013/TT-BTC) and depreciable. The Accounting Standards (169/1999/QD-BTC) define depreciation periods on the basis of the straight-line method. Depreciation must be calculated following the Accounting Standards.

We believe that AFC equipment belongs to the Items C (Measurement/Test Apparatus) and E (Control Apparatus) in the Annex to the Accounting Standards. Each division of equipment is subdivided, and the shortest depreciation period is three years and the longest ten years. Since depreciation is recorded as an expense, companies determine depreciation periods from a business point of view. Longer depreciation periods reduce annual depreciation costs and ease the administrative burden.

If the depreciation period of a ticket gate is set to seven years, for example, the equipment must continue to operate for seven years to contribute to the company, because the expenses are continuously generated. Except in most unusual circumstances, the company does not replace the equipment in less than 7 years considering from a business point of view. In other words, equipment life (durable years) must be at least the depreciation period or longer. On the other hand, equipment with completed depreciation basically contributes to the company’s revenue without generating expenses. The company continues to use the equipment until its failure repair costs exceed an allowable level and its functions become obsolete.

(5) Viewpoint of Electronic Parts

1) Viewpoint of reliability life

As described in the previous section many pieces of AFC equipment are built on the basis of advanced electronics technology. The failures of electronic circuits, therefore, lead to the loss of the main functions of AFC equipment. In the inside of the automatic ticket gate shown in Figure 6-7-18, for example, many circuits and devices are mounted: an electronic control circuit for controlling the door mechanism, LED and LCD panels and their control circuits for displaying information to passengers, an central processing electronic circuit for processing data and controlling the whole equipment, and devices and a reader/writer for safely coding and encoding IC card ticket information.

Fig. 6-7-18 AFC equipment as advanced electronic equipment (example of an automatic ticket gate)

Electronic circuits consist of semiconductor integrated circuits (LSIs), capacitors, resistors, coils, electronic circuit boards, cables, and connectors. The lives of these components have significant effects on the life of AC equipment. In general, electronic components have a bathtub type failure mode. As they approach the end of life, their failure modes change from the random type to the wear-out type, and their failure rates rapidly increase. Electronic components are generally manufactured on the assumption of a life span of about 10 years. Some special use products guarantee a longer life, but they are expensive and unusable for general use. Consequently, the failure rate of AFC equipment may increase after 10 years of use. Then the utilization rate of equipment decreases to increase repair expenses.

2) Viewpoint of the product life (obsolescence) of electronic components

Electronics technology typified by semiconductor integrate circuit technology has greatly advanced after the invention of semiconductor devices in 1947 and that of integrated circuit technology in 1958, changing civilization revolutionarily in less than 70 years. The computer ENIAC, the first computer operated in the USA in

1946, was a huge system with a width of 30 m, a height of 2.4 m, and a depth of 0.9 m. Now we have a handy smartphone with a highly advance computer and a weight of only a little over 100 g. The development of semiconductor technology has been realized along with the prediction known as Moore's Law stating "the number of transistors on integrated circuits doubles approximately every 18 months."

Moore's Law $\mathrm{N} = 2^{n/1.5}$

(Example: The number of elements has increased millionfold in 30 years.)

Electronics technology has been rapidly and continuously developing, resulting in an extremely short life of its applied products. Many people renew their cell phones about every two years. Few people use the same personal computers for five years or more. New products with new functions and a low price are put into market one after another. They become obsolete in a very short period. As a result, the generation of electronic components changes rapidly and manufacturers discontinue old products. AFC equipment, one of electromechanical equipment, is affected by this tendency. Even if the functions of equipment satisfy us and it has a low failure rate, it is highly possible that we cannot obtain the parts needed for repair. Ensuring service parts enables us to cope with this situation to some extent. It would be very expensive, however, to store all parts for repairing the failures of equipment after using it for 10 years or more, taking account of the life of electronic devices. Obsolescence also affects the life of AFC equipment.

(6) Rules on Durable Years

As described above, many factors affect the life of AFC equipment, and hence it is not advantageous to specify the durable year of AFC equipment in a uniform way.

1) Concept of rules on durable years

① Durable years shall be the same as or longer than depreciation period.

② Continuous use if life cycle cost for maintenance is less than renewal cost)
Judgment shall be made comparing a renewal cost of equipment with its life cycle cost including increased repair cost due to increase in failure rate (plus cost to obtain service parts) and increased equipment cost due to decrease in utilization rate.
Such judgment requires the collection, management, and analysis of maintenance data on failure occurrence, repair and recovery time, repair points, used parts, and repair costs as described in the previous section.

③ Prevention of obsolescence

Maintenance cannot be carried out if service parts and consumable parts become unavailable. It is therefore necessary to make maintenance agreements with equipment manufacturers on parts supply.

④ Guideline on durable years

Making rules in a uniform way is difficult. As described in the previous section, electronic circuits realize major functions of AFC equipment. Since the durable years of equipment are determined by the components constituting its electronic circuits, a guideline to judge the durable years of AFC equipment is 10 years, a general life of electronic parts. The utilization rate of equipment should be given attention. Assuming that all stations use the same types and models of equipment, the utilization rate of equipment installed in a city center or a terminal station attracting many passengers is very high, whereas that of equipment installed in a small and empty suburban station is very low. Consequently, even the same models of equipment greatly differ in durable years due to different deterioration progress. The basic rules therefore put the basis on the life cycle costs and renewal costs needed for maintenance.

(7) Methods of Equipment Renewal

In the case where AFC equipment reaches its durable year and is renewed, the following points shall be considered to determine its renewal method:

1) Simultaneous renewal

A method to renew the same types and models of equipment at the same time

2) Separate renewal

A method to renew equipment based on separate judgment on individual piece of equipment.

Table 6-7-28 compares the advantages and disadvantages of the two methods. Both have merits and demerit, and have no definite superiority over the other. When Hanoi Metro’s cash flow is severe, the separate renewal is preferable because of less administrative burden. The general manager of Headquarter Equipment Group needs to make a proposal of separate renewal and carry it out after obtaining the approval based on the rules for equipment investment.

Table 6-7-28 Comparison of equipment renewal methods

Method	Advantage	Disadvantage
Simultaneous renewal	1) Easy to suppress procurement costs because of volume order 2) Also easy to suppress maintenance costs 3) Installment of the same equipment throughout the line increases the usability of passengers.	1) Heavy investment in renewal puts a heavy burden on business. 2) Simultaneous renewal also renews still usable equipment.
Separate renewal	4) Renewing individual equipment separately is effective to suppress investment value. 5) Fixed costs decrease because of individual renewal judgment and possibility of using equipment until the end of its life.	3) Smaller procurement quantity makes a unit purchase price higher. 4) Mixture of different generation equipment increases management costs due to the diversification of service parts.

Appendix 8-6-7-3-B(A) Rules for Criteria on the Number of Installed Equipment

1. The most important factor in determining the number of installed AFC equipment is for passengers to be able to safely and comfortably use urban railways utilizing AFC equipment. The following parameters are essential to ensure safe and comfortable railway use:
   (1) Number of passengers using AFC equipment
   (2) Time for AFC use

   Knowing these parameters enables determining the number of installed AFC equipment referring to equipment performance.
2. Calculation of the number of passengers using AFC equipment
   (1) The number of passengers using AFC equipment is a total of passengers coming to stations to take a train and arriving at stations to leave a train and go out of the station. Since a majority of passengers using urban railways are commuters, they tend to concentrate in stations during the morning and evening commuting time, or so called rush hours. The number of passengers reaches a peak during the commuting time, which is sometimes called peak time. AFC equipment must have a capacity to handle passengers in a safe and comfortable way during the peak time.
   (2) Train operation schedules also affect the number of passengers during peak time significantly. The number of passengers at the time of departure and arrival changes greatly depending on the operation intervals and sets of trains. In the case of train sets with a large number of vehicles, the peak numbers of arriving passengers tend to be larger than those in the case with a small number of vehicles, even when the operation intervals of the former is longer than those of the latter. When calculating the number of passengers, it is essential to clarify the peak numbers of passengers referring to train operation schedules, in addition to the daily number of passengers using stations.
   (3) Time for AFC use

   Time for AFC use means the time needed for processing when a passenger uses a ticket gate or an automatic ticket vending machine. For example, if we assume that the processing time of a ticket gate is 2 seconds per passenger, the gate can check the IC tickets of 30 passengers per minute. Knowing peak time periods and the number of passengers to be handled, the necessary number of ticket gates can be calculated based on the processing capacity of the ticket gate. Beside the processing ability of the equipment itself, the degrees of proficiency of passengers for using the equipment and variation in their walking speeds also affect overall processing capacity. Collecting necessary data based on the above consideration enables the calculation for ticket gates. Automatic ticket vending machines and the processing at windows require different concepts. For example, the time needed for processing a passenger using an automatic ticket vending machine, the number of passengers per minute seeking to use the machine, and resultant average waiting time should be clarified. This kind of questions is known as a "queuing problem," and solved using an M/M/n model. In this case, the waiting time becomes infinite unless the average utilization rate is 1.0 or less, resulting in filling the station yard with passengers. The numbers of installed equipment and windows must therefore be determined to make the average utilization rate sufficiently smaller than 1.0. The M/M/n model expresses the above as follows:

Average utilization rate(ρ) $= \frac{\lambda}{\mu \times N}$

Average number of waiting passengers $= \frac{\rho}{1-\rho}$

Average waiting time $\quad \mathrm{Tw} = \mathrm{Ts} \times \frac{\rho}{1-\rho}$

where,
N: Number of installed equipment (number of windows)
λ: Average arrival rate (number of arriving passengers per unit time)
μ: Average service rate (number of passengers handled per unit time)
Ts: Time used for a passenger

The average arrival time is, for example, means the figure of the number of passengers coming to the automatic ticket vending machine for taking a train at the station divided by the peak time duration. The average service rate means the number of passengers processed by the automatic ticket vending machine per unit time, and depends on equipment performance. The time used for a passenger (Ts) means the time needed for a passenger to purchase an IC ticket using the automatic ticket vending machine.

As an example, we assume that 12,000 passengers come to a station during one hour of peak time, and 50% of them use automatic ticket vending machines to purchase a single ticket. Assuming that the machine can process 240 persons/hour (15 seconds/person), the following expression must hold:

$$\rho = \frac{6000}{240 \times N} \ll 1$$

We can then conclude from the following that the number of required equipment is larger than 25.

$$N \gg \frac{6000}{240} = 25$$

Incidentally, we can also solve the problem as shown below. We assume that a number of P (persons) passengers come to the station during peak time, and that they can commute on time if the operation schedule is developed to transport the passengers within this time duration. For that purpose, N units of automatic ticket vending machines must perform processing at the speed below.

$$N = \frac{P}{S}$$

P is the number of passengers coming to the station in 1 hour.
S is the number of passengers processed per hour

Using the previous example and assuming that P = 6000 persons /hour, and S = 240 persons, we can obtain the result below, which is the same as that based on the queuing theory.

$$N = \frac{6000}{240} = 25\ (units)$$

It must be noted here that the operation specifications of IC train tickets also affect the necessary number of equipment. For example, operation specifications require selling a single ticket with a deposit. In this case, passengers need to receive the deposit when arriving at their destination stations. Since automatic ticket vending machines or windows pay back deposits, the number of passengers coming to the machines or window increases compared to the case with no deposit, resulting in the increased number of installed AFC equipment.

3. Number of Installed AFC Equipment

Using the data collected following the concepts described in the previous sections (2) and (3) enables the calculation of the number of installed equipment. The following must be considered before finally determining the number of installed equipment:

(1) Consideration to disabled persons

Wheel chairs cannot pass the passage widths of standard type ticket gates. From a barrier-free viewpoint, at least one wide type ticket gate should be installed at a station gate.

(2) Consideration of backups

In the case of small stations and station gates where a small number of passengers is predicted, calculation of the necessary number of installed ticket gates may give the result that one unit is enough for each station gate. This result is, however, not appropriate because passengers cannot go in or out of the station if the equipment fails. The station needs to provide at least one passage even during failure time. In this case, therefore, the station needs to add one unit for entering and one for exiting, respectively.

(3) Reduction of the number of installed equipment using bidirectional ticket gates

For example, in the case of terminal stations, the number of passengers taking a train in the morning commuting time may be overwhelmingly larger than that leaving the train.

On the contrary, in the evening commuting time, the number of passengers leaving a train may be overwhelmingly larger than that taking the train. Handling such movement of passengers with one-way ticket gates (which can handle only one direction of passengers: entering or exiting) is not desirable from the viewpoint of the effective utilization of equipment, because most of exiting ticket gates are not used in the morning, and vice versa in the evening.

In such cases, installing bidirectional ticket gates, and setting a necessary number of them for entering in the morning and vice versa in the evening enables effective use of equipment.

The results of analyzing the movement of entering and exiting passengers by time duration must therefore be reflected in determining the number of installed equipment.

(4) Reduction of the number of installed equipment using multifunctional equipment

A minimum number of automatic ticket vending machines or add value machines would be satisfactory for small stations with a small number of passengers (backups are needed). In such cases, installing multifunctional AFC equipment with both functions of an automatic ticket vending machine and an add value machine would be better to reduce the number of installed equipment and save investment and maintenance costs and installation spaces than installing single function AFC equipment.

4. Number of installed equipment of Line 2A

   When detailed data on the number of passengers of Line 2A and the processing capacity of AFC equipment are obtained; we will handle this issue for the training of practical calculation methods.

Appendix 8-6-7-3-C (A) Approach for formulating an equipment replacement plan

The AFC equipment is electronic machine equipment that is controlled electronically and equipped with plenty of electronic parts such as capacitors, resistors, semiconductor parts, switches, and batteries.

Service lives of these electronic parts are about 10 years, making the operating life of the AFC equipment shorter than that of other railway facilities. In addition, electronic technology advances significantly fast enough to allow the evolution to better facilities with higher cost-effectiveness. Therefore, it is necessary to keep an eye on technical trends in equipment replacement and proceed in a systematic manner

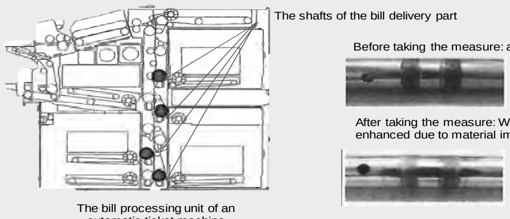
1. An equipment replacement plan should be formulated from a mid- and long-term viewpoint. It should be prepared in line with the background above stated, taking into consideration the following points:
   (1) Measures against failures in an early period after equipment installation and for quality improvement.
   (2) The measure for quality improvement should be introduced into the equipment during an overhaul period after verification of its effectiveness.
   (3) Planned replacement of aged parts that will be needed in the latter period of the equipment service life.
   (4) Systematic promotion of equipment replacement that should be carried out after its service life is over (to be completed in one to two years).
      1) If replacement is implemented in a short period of time, it would cause pressure on management due to a huge investment required in the short period.
      2) However, if replacement is implemented over a long period of time, maintenance is required for both new and old types of facilities, resulting in higher maintenance costs.
2. An example of formulation of a plan is shown in Table 6-7-29 below:

Table 6-7-29 Formulation of an equipment replacement plan

Fiscal Year			1	2	3	4	5	6	7	8	9	10	11	12
			Q1 Q2 Q3 Q4	Q1 Q2 Q3 Q4	Q1 Q2 Q3 Q4	Q1 Q2 Q3 Q4	Q1 Q2 Q3 Q4	Q1 Q2 Q3 Q4	Q1 Q2 Q3 Q4	Q1 Q2 Q3 Q4	Q1 Q2 Q3 Q4	Q1 Q2 Q3 Q4	Q1 Q2 Q3 Q4	Q1 Q2 Q3 Q4
Phase of Equipment			Period of initial failure occurrence/Period for equipment quality improvement			Stable period/Overhaul period				Period of equipment aging/Period for studying next-generation equipment			Period for equipment replacement	
				Defects liability period (DLP; subject to contract conditions) set for the manufacturer					Period for paid maintenance by the manufacturer (subject to contract conditions)					
Quality Improvement Measures	Equipment	Items to be improved (example)												
	Automatic ticket gate	IC card verification software bugs		Collection of information on failure events and analyses of their causes										
		Malfunctions occur frequently at movable parts of the door and the ticket collection unit.												
		Aging proceeds rapidly at movable parts of the door and the ticket collection unit.												
		Sensors malfunction often.		Study of improvement measures										
		Prone to corrosion.												
		Door materials are vulnerable and easy to break.		Trial production and tests by the manufacturer										
		Structure making the maintenance work difficult.			Field test									
	Automatic Ticket Machine	Fare processing software bugs												
		Malfunctions occur frequently in the bill/coin processing units and the IC card processing unit.				Preceding introduction into restricted locations (on trial)								
		Aging proceeds rapidly at movable parts of the bill/coin processing units and the IC card processing unit.												
		Dust enters easily.					Full introduction into equipment (Introduction of quality improvement measures can reduce equipment failures and maintenance costs.)							
		Prone to corrosion.												
		Structure making the maintenance work difficult.												
	Ticket office machine	Software bugs												
		Malfunctions occur frequently at the movable parts of the IC card processing unit.												
		Aging proceeds rapidly in the movable parts of the IC card processing unit.												
		Dust enters easily.												
		Prone to corrosion.												
		Difficult to do the maintenance work.												
	Station controller	Software bugs												
		Frequent communication errors												
	Train line server	Software bugs												
		Frequent communication errors												
		Insufficient memory capacity												
		Slow processing speed												
Measures against Aging	Failures tend to occur more frequently as each piece of equipment gets close to the end of its service life. It is necessary to analyze failure information and formulate a replacement plan. Ex) Aging of the batteries mounted in the electronic circuits.									Planning and implementation of replacement of aged parts (batteries in the electronic circuits, etc.)				
Replacement with new equipment for the next term										Formulation of basic specifications of equipment for the next term (functions, performance and costs)				
	Requirements for equipment for the next term													
	Development and trial production										Development and trial production			
	Factory test											Factory test		
	Field test											Field test		
	Prior installation												Prior installation	
	Full installation												Full installation	

● Example of quality improvement measures

～A measure against the problem of rapid wear on the shafts and frequent malfunctions～



The bill processing unit of an automatic ticket machine

Appendix 8-6-7-3-D(A) Concept of developing the standard for the number of AFC equipment installations

1. Basic concept of developing the standard for the number of installations

The automatic fare collection (AFC) equipment is used to allow passengers to purchase train tickets and pass ticket gates, thus is deeply related to the safety and convenience of passengers. Accordingly, it is an underlying principle to emphasize these two aspects when determining the number of installations.

2. Method for determining the number of AFC equipment installations

The AFC system are usually classified into six levels, as shown in the following figure, each of which has a different concept of determining the number of installations.

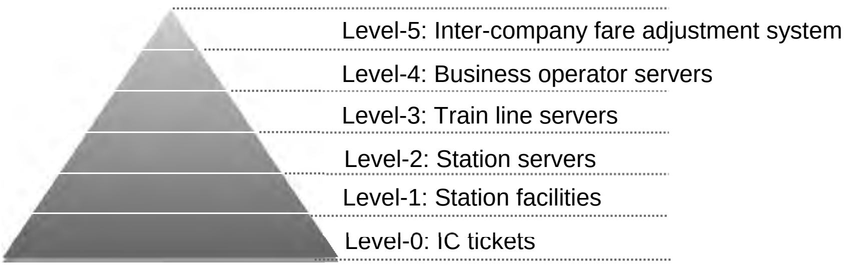


Fig. 6-7-19 Structure and facilities of the AFC system

(1) Level-5

A system to process data of multiple transportation operators. It is not under the jurisdiction of Hanoi Metro, and thus it is not covered in this study.

(2) Level -4 to Level-3

1) Computer systems for data processing and communication, consisting of the main bodies of computers, storage devices, workstations for operation, local area network facilities, and so on.

2) Their system configuration is decided based on necessary processing capacity, memory capacity, etc. To secure their continued operation even at the time of failure or maintenance, multiplexing of equipment and other methods are adopted. However, basically, each system is handled independently, and usually only one system is installed.

3) A business operator server at Level-4 influences the whole route if it fails to operate properly. For this reason, equivalent systems are sometimes built in two or more bases to allow for sustain functions of the business operator server even if a flood, a fire, or any

other disaster inflicts catastrophic damage on facilities. However, as it requires huge expenses, such measures should be judged before implementation in terms of risks and costs.

(3) Level-2

A station server is a computer system installed in each station to monitor ticket gates, ticket machines, and other station facilities, collect and process data from station facilities, distribute “Blacklist” data to the station facilities, and so on. If the number of passengers is extremely small and an amount of data to be processed is small in a station, a station server may not be installed there; instead, the station may be connected with a station server in another station. However, basically one system is installed in each station.

(4) Level-1

Station facilities include ticket gates, ticket machines, ticket office machines, and so on. Because the number of these machines installed is directly related to the safety and convenience of passengers, the number is usually determined based on the concepts described below:

1) Automatic ticket gate (AG)

a. Basic concepts

The number of installations should be determined to allow passengers to swiftly enter and exit from stations.

In urban railways, passengers cannot enter or exit from station premises unless their IC tickets are verified at ticket gates. It means that if the processing capacity of the ticket gates is low, the station premises would be crowded with passengers who get off the train and, in the worst case, platforms would also be filled with passengers, which might cause accidents such as passenger’s contact with a train. In addition, under such conditions, passengers who have bought tickets and try to get on a train might miss the train. For this reason, it is important to have passengers swiftly enter and exit from station premises.

b. Method for determining the number of installations (one example)

i. In urban railways, students and workers who commute by train account for a large percentage of all the passengers. Accordingly, passengers are more likely to concentrate at morning and evening commuting times. Ticket gates need to have ticket processing capacity large enough to cope with passengers concentrated at peak times.

ii. Obtain the number of passengers who enter the station premises (α) and the number of passengers who exit from the station premises (β) at peak times for each station with reference to transportation plans and data on the number of passengers.

iii. Determine the processing capacity (λ) per ticket gate. At this step, it is necessary to regard as the ticket gate capacity the processing capacity obtained by subtracting a degree of passengers' proficiency in dealing with ticket gates from the processing capacity of each ticket gate. In the cases, such as in Vietnam, where most passengers are going to use ticket gates for the first time, this subtracted number must be set large. With the number of installations N, the numbers of ticket gates for exiting from the station premises and for entering them are determined as below:

N (the number of ticket gates for exiting) = $\alpha \div \lambda$
N (the number of ticket gates for entering) = $\beta \div \lambda$

Where, if N is smaller than 2 ($N < 2$), the value of N should be regarded as 2 ($N = 2$).
The reason why N should be equal to or larger than 2 is that if N is one ($N = 1$), there is no checking tickets when the ticket gate malfunctions.
In addition, usually one special ticket gate with a wider path should be installed per entrance and per exit to handle passengers using wheel chairs or carrying large baggage.

c. Control measures on the number of installations

There may be a case where a trend of passengers varies greatly depending on hours (e.g., many passengers board the train at peak times in the morning, while many passengers get off the train at peak times in the evening. In such a case, by installing dual-purpose machines applicable to both entering and exiting passengers and using them for entering in the morning and for exiting in the evening, the total number of ticket gates installed can be reduced.

However, for some time after the operation is launched, it is not easy to grasp a trend of passengers' behaviors, so that it is desirable to make a study of these measures when increasing the number of ticket gates or replacing related facilities.

2) Automatic ticket vending machine (TVM), automatic add value machine (AVM), ticket office machine (TOM), etc.

a. Basic concepts

The time for passengers to wait in line should be considered as an index to measure convenience of passengers. And then, the maximum passenger waiting time should be set, and the number of installations should be determined so as not to exceed this time. Even at peak times, the number of installations must be determined so that passengers can buy IC tickets or charge their IC cards within this maximum waiting time.

b. Method for determining the number of installations (one example)

i. Method

As a means to determine the number of installations based on the maximum waiting time, there is a method of using the queuing theory. Here, the M/M/1 model is explained as an example. Though the M/M/1 model is used when only one machine is used, it can be applied to the case with two or more machines on the assumption that passengers wait in a separate queue respectively. Among calculation models using the queuing theory, there is the M/M/S model that can be applied to the case where two or more (S) machines are installed but passengers wait in a single queue. It is very complicated to make calculations in this model, which requires calculations using computers. Since it is difficult to control how passenger form queues, it would be useful to make a comparison among two or more models.

ii. M/M/1 model and calculation

N : the number of machines to be installed

μ : the average service rate (the number of persons that can be processed in a unit time)

Ts : the time needed to process one passenger

Tw : average waiting time in queue

T :total average waiting time to complete process

γ: the average arrival rate (the number of passengers who arrive in a unit time)

ρ: the average utilization rate (a rate of machines that are used)

Average utilization rate: $\rho = \frac{\gamma}{\mu}$

Average waiting time: $T = Tw + Ts = Ts \times (\frac{\rho}{1-\rho} + 1)$

If the number of machines set up in a row is N and independent queues are formed for each machine as above stated, the arrival rate per queue is between γ and $\frac{\gamma}{N}$, and the average utilization rate is determined as below:

$$\rho = \frac{\gamma}{N \times \mu}$$

Now estimate the N using the above. For example, if 60 passengers arrive per minute (γ) and a machine can handle three passengers per minute (μ; Ts=20 sec), the corresponding number of machines is calculated as 21.4 with the maximum passenger waiting time of 5 minutes, as shown below. Through rounding up, the number of installations is determined as 22.

$$\mathrm{N} = \frac{\gamma \times T}{\mu \times (T - Ts)} = \frac{60 person/min. \times 300 sec}{3 person/min. \times (300 sec - 20 sec)} = 21.4$$

iii. Relation between the operation method of IC tickets and the number of machines

Here attention should be paid to the fact that the operation specifications of IC tickets have an influence on the necessary number of machines. For example, when single journey tickets (SJTs) are sold with deposits included, passengers use automatic ticket vending machines or come to the ticket office for a refund of the deposits. Therefore, in this case, more passengers use automatic ticket vending machines or the ticket office than in the case where deposits are required. As a result, the number of required AFC machines will be increased.

iv. Control of the number of installations by use of multifunctional machines

When installing machines with multiple functions, specifically the dual functions of an automatic ticket vending machine and an add value machine, instead of a single-function type of AFC machines, a per-unit cost increases. However, in most cases, it can reduce the number of installations, the amount of investments, maintenance costs, and the installation space.

So, it is thought that this is an issue to be studied when replacing the machines after data related to a trend of activities of passengers are accumulated following the launch of operation.

(5) Other equipment and facilities

In addition to the above stated machines, the AFC system includes the equipment to issue IC tickets and facilities to provide education and training for staff.

1) Equipment to issue IC tickets

It consists of the IC card initializer, the registered-ticket face printer, the controller of these machines and so on.

The number of installations of each machine is determined by dividing the number of IC tickets needed monthly by the processing capacity of each machine. However, because the issuance of IC tickets cannot be stopped even when the machines fail, backup machines should be prepared.

2) Facilities for education and training of staff

These facilities are used to educate and train staff about operation of the AFC system. It is necessary to implement functions of the AFC equipment at Level-1 to Level-4. If the actual AFC system is used for training, there will be a risk of causing a trouble due to erroneous operations. Therefore, a separate system is necessary. But, if all the machines are installed, the cost burden will increase. Accordingly, there is an option to install station facilities and station servers of the minimum structure for two stations and emulate facilities at Level-3 and Level-4 on the servers.

Appendix 8-6-7-4-A(A) Learning of Measures to Prevent Equipment Failures (AFC)

(Including formulation of the equipment operation safety manual that covers response actions to accidents)

It is often thought that realization of safe and highly reliable equipment, where failures seldom occur, is work that falls into a category of maintenance and preservation.

However, if material without good corrosion resistance is used as metallic material for chassis of equipment, it soon gathers rust on it in such an environment with high temperature and high humidity as Vietnam. Furthermore, as equipment such as automatic ticket gates are installed at places where many passengers come and go, they are exposed to not only dusts but also wind and rain depending on an installation environment. Without drip-proof and dust-proof design, it is difficult to reduce failures no matter how much efforts are made for maintenance and preservation.

As stated above, it can be understood that parties concerned must start their efforts from the phase of making the concept and design of equipment in order to realize equipment with safety and high reliability. On the other hand, it is important for staff to operate equipment in a correct and safe manner in order to prevent failures and realize highly reliable operation. It requires efforts with a focus on “human beings.”

Figure 6-7-20 indicates that efforts with a focus on “equipment” and “human resources” are an element for realizing equipment that is safe and highly reliable as discussed above.

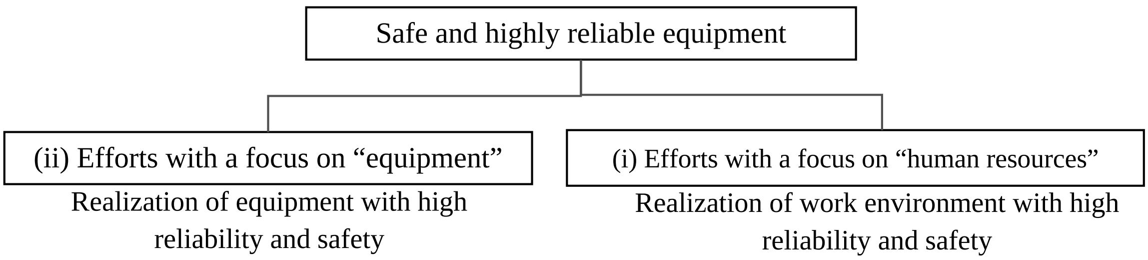


Figure 6-7-20 Elements for realizing safe and highly reliable equipment

1. Efforts with a focus on equipment

1.1. Introduction of international standards

International standards related to safety and reliability are specified in a detailed manner according to usage of equipment. These standards prescribe contents internationally accepted as requirements for safety and reliability. Therefore, by introducing these standards requirements for equipment can be met.

Also, as a secondary effect of introduction of the standards, it can be easily confirmed if equipment meets appropriate requirements by defining the introduced standards. However, in most cases, provisions mentioned in standards are performance provisions that specify capability and performance to be fulfilled by equipment but not specification provisions. Unlike specification provisions, performance provisions do not uniquely define the design of equipment but allows various types of design even if they are based on the same standards. Therefore, it should be noted that if only adequate standards are applied, they cannot decide a level of safety and reliability of equipment. It should be noted that it is necessary to inspect and assess what design is made based on standards and whether target levels are met by safety and reliability that can be achieved by the design.

Incidentally, there are many standards concerning reliability and safety. Therefore, attention should be paid to a necessity of choosing and adopting standards by fully examining a particular field, usage, and other conditions of target equipment.

As shown in Figure 6-7-21, there are categories in standards related to reliability and safety of electromechanical system equipment. These categories are called (i) the basic safety standard that defines basic principles, (ii) the group safety standard applicable to a wide range of equipment regardless of fields, and (iii) the safety standard for each field that defines standards for specific fields.

Fig. 6-7-21 Structure of standards

i. Basic safety standards

This standard prescribes basic concepts and design principles. It is also called the A Standard.

ii. Group safety standards

This standard is related to safety, safety-related devices, etc. regardless of usage of equipment. Most of contents for mechanical systems are defined in ISO, and contents for electrical systems are defined in IEC. It is also called the B Standard.

iii. Safety standards for each field

Because requirements to be met are different in each application (field) of equipment, a standard for each field is defined. In the railway field, the standard known as Railway RAMS falls into this category. It is also called the C Standard.

iv. Quality management standards

This standard is related to quality management. A higher level of quality management should be implemented in order to carry out design, development, manufacturing, installation, and operation of equipment with introduction of standards ranging from the basic safety standard to the safety standard for each field.

v. Ergonomics standards

This is a standard based on ergonomics to prevent a mental load imposed on persons in charge of equipment from excessively increasing.

Table 6-7-30 lists international standards related to AFC, according to categories above mentioned. Incidentally, it should be noted that it does not covers all the standards, and specifically it does not indicate domestic laws, standards, and rules of Vietnam. Therefore, applicable standards must be selected by collecting the latest information.

Table 6-7-30 Examples of international standards related to reliability and safety of equipment

Category	Standard No.	Scope of application
Basic safety standards - Basic concepts - Design principles	ISO/IEC Guide51	Safety Aspects－Guidelines for their inclusion in standards
	IEC Guide 104	The preparation of safety publications and the use of basic safety publications and group safety publications
	ISO 12100:2010	Safety of machinery -- General principles for design -- Risk assessment and risk reduction
	ISO/TR 14121-2	Safety of machinery -- Risk assessment -- Part 2: Practical guidance and examples of methods
	IEC 60529	Degrees of protection provided by enclosures (IP Code)
	IEC 60664	Insulation coordination for equipment within low-voltage systems - ALL PARTS
	IEC 61140	Protection against electric shock - Common aspects for installation and equipment
	IEC 61508	Functional safety of electrical/electronic/programmable electronic safety-related systems
Group safety standards - Safety standards applicable to a wide range of mechanical equipment **(mechanical**	ISO 3741	Acoustics -- Determination of sound power levels and sound energy levels of noise sources using sound pressure -- Precision methods for reverberation test rooms
	ISO 10816	Mechanical vibration -- Evaluation of machine vibration by measurements on non-rotating parts – Part 1: General guidelines Part 3: Industrial machines with nominal power above 15 kW and nominal speeds between 120 r/min and 15 000 r/min when measured in situ
	ISO 13849	Safety of machinery -- Safety-related parts of control systems –

Category	Standard No.	Scope of application
system)		Part 1: General principles for design Part 2: Validation
	ISO 13850	Safety of machinery -- Emergency stop -- Principles for design
	ISO 13851	Safety of machinery -- Two-hand control devices -- Functional aspects and design principles
	ISO 13854	Safety of machinery -- Minimum gaps to avoid crushing of parts of the human body
	ISO 13855	Safety of machinery -- Positioning of safeguards with respect to the approach speeds of parts of the human body
	ISO 13856	Safety of machinery -- Pressure-sensitive protective devices – Part 1: General principles for design and testing of pressure-sensitive mats and pressure-sensitive floors Part 2: General principles for design and testing of pressure-sensitive edges and pressure-sensitive bars Part 3: General principles for design and testing of pressure-sensitive bumpers, plates, wires and similar devices
	ISO 13857	Safety of machinery -- Safety distances to prevent hazard zones being reached by upper and lower limbs
	ISO 14118	Safety of machinery -- Prevention of unexpected start-up
	ISO 14119	Safety of machinery -- Interlocking devices associated with guards -- Principles for design and selection
	ISO 14120	Safety of machinery -- Guards -- General requirements for the design and construction of fixed and movable guards
	ISO 14122	Safety of machinery -- Permanent means of access to machinery – Part 1: Choice of fixed means of access between two levels

Category	Standard No.	Scope of application
		Part 2: Working platforms and walkways Part 3: Stairs, stepladders and guard-rails Part 4: Fixed ladders
	ISO 14123	Safety of machinery -- Reduction of risks to health from hazardous substances emitted by machinery – Part 1: Principles and specifications for machinery manufacturers Part 2: Methodology leading to verification procedures
	ISO 14159	Safety of machinery -- Hygiene requirements for the design of machinery
	ISO/TR 23849	Guidance on the application of ISO 13849-1 and IEC 62061 in the design of safety-related control systems for machinery
Group safety standards - Safety standards applicable to a wide range of electrical equipment (electrical system)	IEC 13850	Safety of machinery - Emergency stop - Principles for design
	IEC 60076	Power transformers - ALL PARTS
	IEC 60079	Explosive atmospheres – Part 0: Equipment - General requirements Part 1: Equipment protection by flameproof enclosures "d" Part 2: Equipment protection by pressurized enclosures 'p' Part 5: Equipment protection by powder filling 'q' Part 6: Equipment protection by oil immersion 'o' Part 7: Equipment protection by increased safety 'e'

Category	Standard No.	Scope of application
		Part 11: Equipment protection by intrinsic safety 'i' Part 13: Equipment protection by pressurized room 'p' Part 15: Equipment protection by type of protection 'n' Part 16: Artificial ventilation for the protection of analyzer (s) houses Part 18: Equipment protection by encapsulation "m" Part 19: Equipment repair, overhaul and reclamation Part 25: Intrinsically safe systems Part 26: Equipment with equipment protection level (EPL) Ga Part 27: Fieldbus intrinsically safe concept (FISCO) Part 28: Protection of equipment and transmission systems using optical radiation Part 29-1: Gas detectors - Performance requirements of detectors for flammable gases Part 29-4: Gas detectors - Performance requirements of open path detectors for flammable gases Part 30-1: Electrical resistance trace heating - General and testing requirements Part 31: Equipment dust ignition protection by enclosure "t" Part 35-1: Caplights for use in mines susceptible to firedamp - General requirements - Construction and testing in relation to the risk of explosion
	IEC 60204	Safety of machinery - Electrical equipment of machines – Part 1: General requirements Part 11: Requirements for HV equipment for voltages above 1 000 V a.c. or 1 500 V d.c. and not exceeding 36 kV

Category	Standard No.	Scope of application
		Part 32: Requirements for hoisting machines
	IEC 60364	Part 1: Fundamental principles, assessment of general characteristics, definitions Part 4-41: Protection for safety - Protection against electric shock Part 4-42: Protection for safety - Protection against thermal effects Part 4-43: Protection for safety - Protection against overcurrent Part 4-44: Protection for safety - Protection against voltage disturbances and electromagnetic disturbances Part 5-51: Selection and erection of electrical equipment - Common rules Part 5-52: Selection and erection of electrical equipment - Wiring systems Part 5-53: Selection and erection of electrical equipment - Isolation, switching and control Part 5-54: Selection and erection of electrical equipment - Earthing arrangements and protective conductors Part 5-55: Selection and erection of electrical equipment - Other equipment Part 5-56: Selection and erection of electrical equipment - Safety services Part 6: Verification Part 7-714: Requirements for special installations or locations - External lighting installations Part 7-715: Requirements for special installations or locations -Extra-low-voltage lighting installations Part 7-717: Requirements for special installations or locations -Mobile or transportable units Part 7-718: Requirements for special installations or locations - Communal equipment and workplaces Part 7-722: Requirements for special installations or locations - Supplies for electric vehicles Part 7-729: Requirements for special installations or locations - Operating or maintenance gangways Part 7-740 : Requirements for special installations or locations - Temporary electrical installations for structures,

Category	Standard No.	Scope of application
		amusement devices and booths at fairgrounds, amusement parks and circuses Part 7-753: Requirements for special installations or locations - Heating cables and embedded heating systems Part 8-1: Energy efficiency
	IEC 61000	Part 1: General - the safety function requirements (what the function does); and - the safety integrity requirements (the likelihood of a safety function being performed satisfactorily). Part 2: Environment - Description of the environment - Classification of the environment - Compatibility levels Part 3: Limits - Emission limits - Immunity limits (insofar as they do not fall under the responsibility of product committees) Part 4: Testing and measurement techniques - Measurement techniques - Testing techniques Part 5: Installation and mitigation guidelines - Installation guidelines - Mitigation methods and devices

Category	Standard No.	Scope of application
		Part 6: Generic standards Part 9 : Miscellaneous
	IEC 61310	Safety of machinery - Indication, marking and actuation – Part 1: Requirements for visual, acoustic and tactile signals Part 2: Requirements for marking Part 3: Requirements for the location and operation of actuators
	IEC 61496	Safety of machinery - Electro-sensitive protective equipment – Part 1: General requirements and tests Part 2: Particular requirements for equipment using active opto-electronic protective devices (AOPDs) Part 3: Particular requirements for Active Opto-electronic Protective Devices responsive to Diffuse Reflection (AOPDDR) Part 4: Particular requirements for equipment using vision based protective devices (VBPD)
	IEC 62046	Safety of machinery - Application of protective equipment to detect the presence of persons
	IEC 62061	Safety of machinery - Functional safety of safety-related electrical, electronic and programmable electronic control systems
	IEC 62513	Safety of machinery - Guidelines for the use of communication systems in safety-related applications
	IEC 61508	Functional safety of electrical/electronic/programmable electronic safety-related systems Part 1: General requirements Part 2: Requirements for electrical/electronic/programmable electronic safety-related systems

Category	Standard No.	Scope of application
		Part 3: Software requirements Part 4: Definitions and abbreviations Part 5: Examples of methods for the determination of safety integrity levels Part 6: Guidelines on the application of IEC 61508-2 and IEC 61508-3 Part 7: Overview of techniques and measures
	IEC 60947	Low-voltage switchgear and control gear – Part 1: General rules Part 2: Circuit-breakers Part 3: Switches, disconnectors, switch-disconnectors and fuse-combination units Part 5-1: Control circuit devices and switching elements - Electromechanical control circuit devices Part 5-5: Control circuit devices and switching elements - Electrical emergency stop device with mechanical latching function Part 5-8: Control circuit devices and switching elements - Three-position enabling switches
Safety standards for each field **(railway equipment)**	IEC 62278	Railway applications - Specification and demonstration of reliability, availability, maintainability and safety (RAMS)
	IEC 62278-3	Part 3: Guide to the application of IEC 62278 for rolling stock RAM
	IEC 62279	Railway applications - Communications, signaling and processing systems - Software for railway control and protection systems
	IEC 62425	Railway applications - Communication, signaling and processing systems - Safety related electronic systems for signaling

Category	Standard No.	Scope of application
Quality management standards	ISO 9000	Quality management systems -- Fundamentals and vocabulary
	ISO 9001	Quality management systems -- Requirements
	ISO 9004	Managing for the sustained success of an organization -- A quality management approach
Ergonomics standards (related to mental workloads)	ISO 10075	Ergonomic principles related to mental work-load – Part 1: General terms and definitions Part 2: Design principles Part 3: Principles and requirements concerning methods for measuring and assessing mental workload

1.2. Individual mechanical safety standards in the railway sector (Railway RAMS)

Railway equipment is directly linked with safety of passengers, and railways are important social infrastructures that support social activities. Accordingly, it is requested to achieve a high level of safety and reliability. For this reason, each country has specified mechanisms and systems to achieve and maintain reliability and safety of railway equipment.

The safety standard for each field related to railway equipment consists of IEC 62278, IEC 62278-3, IEC 62279, and IEC 62425, as shown in Table 6-7-30 of the preceding Section. Among them, IEC 62278 occupies a key position.

These standards define a scheme called Railway RAMS, and it is thought that elements indicated in Figure 6-7-22 have influences on Reliability, Availability, Maintainability and Security. It is subject to an idea that reliability and safety of equipment are attained through integration of features of constituent elements.

In Railway RAMS, with a focus on these constituent elements through equipment life cycles, efforts to control RAMS indexes (reliability and safety) of equipment are pursued by implementing the following processes.

i. Classify equipment life cycles into phases.
ii. Categorize equipment into constituent elements (subsystems and constituent parts).
iii. Index RAMS targets at each phase of a life cycle of each constituent element.
iv. Proceed with phases of a life cycle while demonstrating fulfillment of required items.

As shown in Table 6-7-31, a life cycle consists of 14 phases. To set RAMS targets, a fault tree analysis (FTA) and a hazard analysis are performed for clarification of processes. And, it follows a scheme where third parties evaluate target setting, implementation details and results so as to objectively assess their adequacy.

In most cases, countries newly starting to develop urban railways have not enough accumulation of domestic technologies and human resources with good experiences. In such a case, they have to introduce technologies from abroad.

Generally speaking, knowledge such as technology assets and experiences is divided into (i) formal knowledge, explicitly indicated in documents, graphic charts, mathematical expressions, and so on, and (ii) implicit knowledge such as experiences and intuitions that cannot be explicitly indicated. It is easier to handle formal knowledge in the transfer of knowledge. It goes the same way when introducing technologies to establish reliability and safety in railways; the more technological knowledge is in the form of formal knowledge, the easier to transfer.

The basis of Railway RAMS is indexing of targets, clarification of processes, and work based on documents. It also defines processes for evaluation and assessment by third parties. In addition, due to the background stated above, there are an increasing number of cases of adopting Railway RAMS in countries starting to newly construct railways.

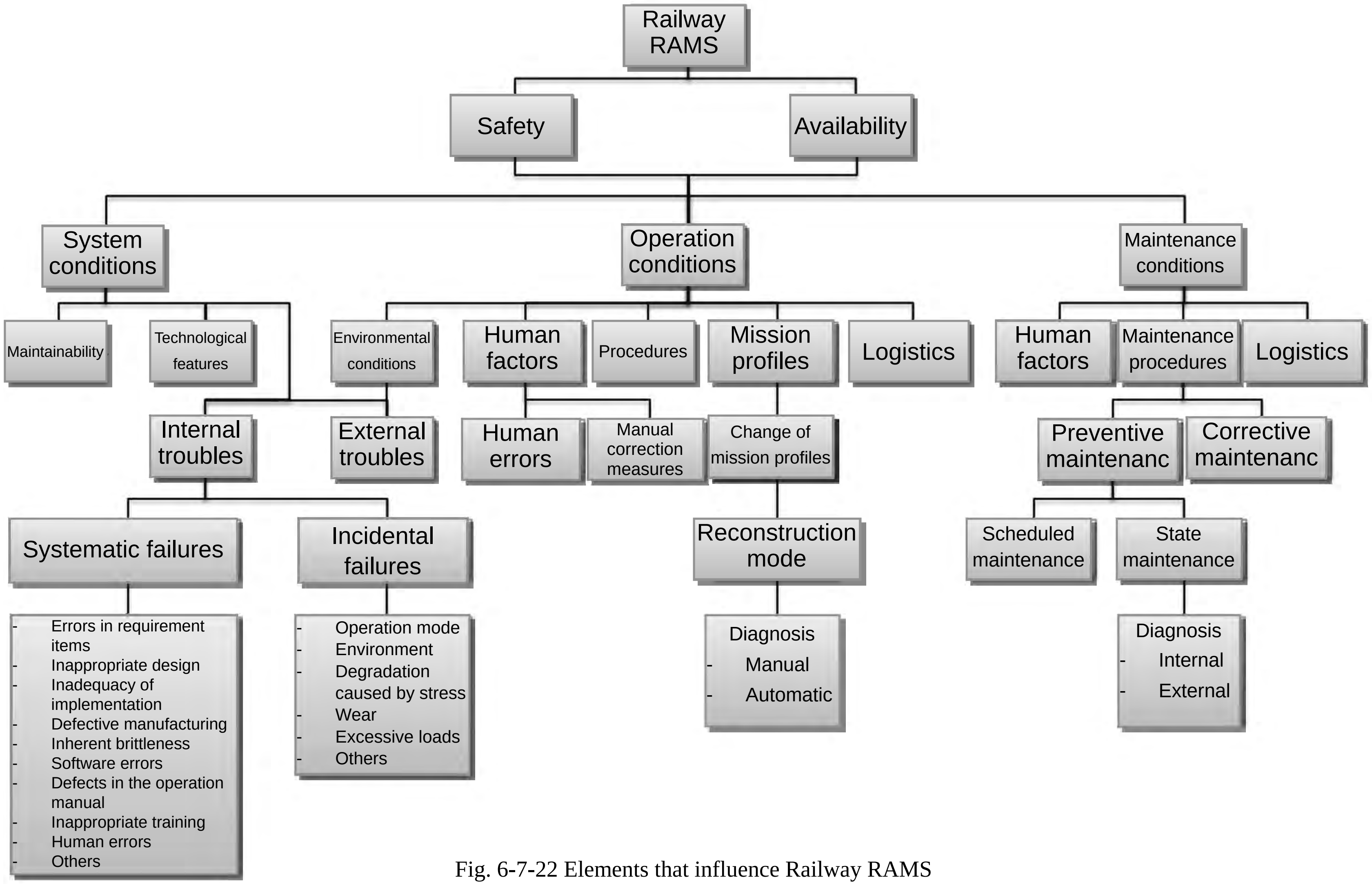


Fig. 6-7-22 Elements that influence Railway RAMS

Table 6-7-31 Definition of life cycle in RAMS

No.	Each phase of a life cycle	Objective of each phase
1	Concept	• Clarification of system objectives and scopes of tasks
2	System definition and applicable conditions	• Define the system mission and features; the scope of hazard analysis; RAMS policies, objectives, operation, maintenance policies, and interfaces with other systems; a safety plan, etc. a. Define the scope of the target system. (Define the boundary.) b. Define impact conditions on the target system that influence features of the system. c. Define the scope of a hazard analysis of the system. d. Set up the RAMS policy concerning the target system. e. Formulate a safety plan (*) of the target system. (*) A safety plan is a plan document with descriptions of milestones and implementation items along with a time axis so as to set up an organization, an accountability system, work procedures, implementation contents, and response capability for the purpose of making target equipment ensure safety requirement items specified in a prescribed contract or project.
3	Risk analysis	Perform a hazard analysis and a risk assessment. a. Specify hazards related to the target system. b. Specify events that may lead to occurrence of a hazard. c. Identify risks accompanying hazards. d. Set up a process to continuously control risks.
4	System requirement items	• For the whole target system, a. Clarify RAMS requirement items, and b. Define RAMS demonstration acceptance criteria. • Make up a RAMS program to manage RAMS work to be conducted at each phase in the successive life cycles.
5	Allocation of system requirement items	• For RAMS requirement items of the whole target system, a. Allocate these items to prescribed subsystems, constituent parts, and external equipment, and b. Define the RAMS acceptance criteria for prescribed subsystems, constituent parts, and external equipment.
6	Design and implementation of a RAMS plan	a. Make subsystems and constituent parts that conform to RAMS requirement items. b. Demonstrate that the subsystems and the constituent parts meet the RAMS requirement items. c. Make a plan related to RAMS for the next phase of the life cycle.
7	Manufacturing	a. Manufacture subsystems and constituent parts whose conformity to RAMS has been demonstrated. b. Define methods of quality assurance and quality maintenance in manufacturing processes based on RAMS.
8	Installation	a. Assemble and install the target system using the subsystems and the constituent parts. b. Start a maintenance system for the target system.
9	Confirmation of system validity	• Confirm conformity to the RAMS requirement items by activating the whole system where all the subsystems, the constituent parts, and external risk reduction means are combined. a. Include acceptance of safety and commissioning. b. Confirm that the whole system where all the subsystems, the constituent parts, and external risk reduction means are combined conforms to the RAMS requirement items of the whole target system. c. Start commissioning of the whole system where all the subsystems, the constituent parts, and external risk reduction means are combined. d. Collect and assess data.
10	System acceptance	• Activate the whole system where all the subsystems, the constituent parts, and external risk reduction means are combined; assess its conformity to the comprehensive RAMS requirement items; and start operation of the system if they pass the assessment. a. Make an assessment of conformity of the whole system where all the subsystems, the constituent parts, and external risk reduction means are combined to the comprehensive RAMS requirement items of the whole system. b. Accept the target system to start operation.
11	Operation and maintenance	• Operate, maintain, and support (within a specified limit) in a manner to keep conformity of the combination of all the subsystems, the constituent parts, and external risk reduction means to the RAMS requirement items of the system.
12	Monitoring of performance	• Collect necessary information and data, and monitor the target system to ensure RAMS performance of the system is maintained.
13	Repair and replacement	Manage repair of the system and additional work so as to sustain the RAMS requirement items of the system.
14	Abolition and disinstallation	• Manage work for abolition and disinstallation of the system.

1.3. Relation between the AFC equipment and Railway RAMS

As for Railway RAMS, in the phase 5 of the life cycle, safety functions are allocated to subsystems that constitute equipment and then levels (security integrity level; SIL) corresponding to their degrees of safety are set. This concept is based on IEC 61508.

IEC 61508 is a provision related to functional safety of electrical, electronic, and programmable electronic (E/E/PE) systems. The AFC equipment is E/E/PE-system equipment, so that it is within the scope of application of this standard. However, this standard is just a standard related to functional safety of E/E/PE systems, and thus the other constituent parts are out of the scope of application.

IEC 61508-1 (Part1) has two modes: the low-frequency demand mode of operation and the high-frequency demand mode of operation. And as shown in Table 6-7-32, it defines four levels of safety degrees in each mode (1 – 4). The low-frequency demand mode of operation is a mode where an operation demand of safety functions is issued only once or so per year. For example, life-saving automotive air-bags fall into this mode. The high-frequency demand mode of operation is a mode where such a demand is issued once or more per year. As for the AFC equipment, considering that it is equipment accessed by users from the start to the end of daily service without interruption, it can have an opportunity to activate safety functions once or more per year. Therefore, it seems appropriate to categorize it into the high-frequency demand mode.

A value given to each SIL is a probability of a failure in functional operation when a demand of operation of safety functions is issued. It is expressed with a failure per hour (FPH: /h) in the case of the high-frequency demand mode of operation. The following table includes SIL 0, though IEC 61508 has no description of SIL 0. It was added here for convenience in terms of safety, since it is intended to handle equipment wilt risk low enough to make setting of a security level unnecessary.

Table 6-7-32 Security Integrity Level
(for the high-frequency demand mode of operation)

Security Integrity Level (SIL)	Average frequency (per hour) of a failure of safety functions on the risk side
4	Lower than 10^{-8}/h to 10^{-9}/h
3	Lower than 10^{-8}/h to10^{-7}/h
2	Lower than 10^{-7}/h to10^{-6}/h
1	Lower than 10^{-6}/h to10^{-5}/h
0	10^{-5}/h or higher

To consider what security level the AFC equipment should achieve, an outline of a basic approach to safety and risk will be given with reference to ISO/IEC Guide 51 and IEC 61508.

Guide 51 defines that “Safety means being free from intolerable risk.” It is necessary to pay attention to the fact that Safety is assessed in its relation with risk, and risk exits even in a “Safe” state. This is a different point from the definition of “Safety” in general knowledge.

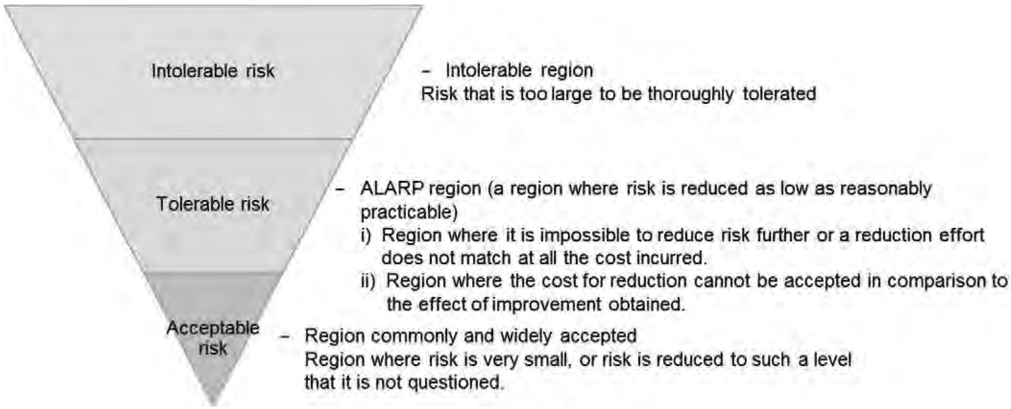


Fig. 6-7-23 Relation between safety and risk

Figure 6-7-23 shows an approach to safety based on Guide 51 and IEC 61508. The safe region consists of the “acceptable risk” and “tolerable risk” regions.

i. “Acceptable risk”
   It is risk of a minor failure if it occurs or risk of a significant failure with extremely low possibility of occurrence. This region is considered unnecessary for measures to be taken for safety. But, there is a need to confirm that a risk remains within this region.

ii. “Tolerable risk”
   It is risk as low as reasonably practicable (ALARP) as shown in the above figure. Though there is a non-negligible risk, it is risk that is impossible to reduce or difficult to reduce due to cost-benefit performance, meaning it is risk in the level acceptable to current social standards. In other words, it is risk that is judged to be acceptable in consideration of the risk level and convenience.

In the AFC system, there is no denying a risk that a passenger has his/her body caught by the gate of an automatic ticket gate. However, a risk that becomes fatal to humans or causes severe impairment is extremely low, so that risks related to the AFC equipment are thought to be “acceptable risks.” And, in most cases, they are ranked as SIL0, and thus evaluation and assessment of their safety levels are not required.

One of the effective methods to decide SIL is the risk graph. In the risk graph, a risk is expressed as below:

$$R = f(C, F, P, W)$$

R: Risk f: Function F: Exposure frequency and time to a danger
C: Result after a dangerous event happens P: Possibility to avoid a danger
W: Event probability of an undesired event

Where, C, F, P, and W are called risk variables.

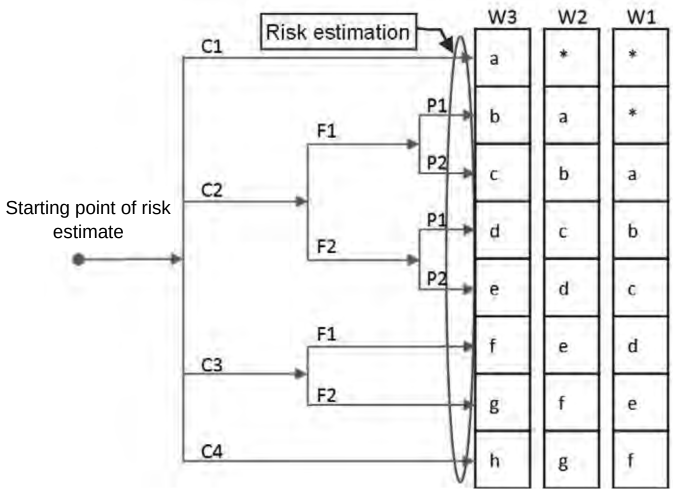


Fig 6-7-24 Application example of risk graph

Table 6-7-33 Risk variables and risk elements

Risk variable	Risk element	Meaning of element
Result after a dangerous event occurs	C1	Minor
	C2	Severe injury or death
	C3	Multiple deaths
	C4	Many deaths
Exposure frequency and time to a danger	F1	Rarely to often
	F2	Frequently to permanently
Possibility to avoid a danger	P1	Possible depending on conditions
	P2	Almost impossible
Event probability of an undesirable event	W1	Minute
	W2	A little
	W3	Relatively high

Table 6-7-34 Example of response to risk estimation

Risk reduction request class	Safety integrity level
*	No safety requirement items
a	No special safety requirement items
b, c	SIL 1
d	SIL 2
e, f	SIL 3
g	SIL 4
h	Insufficient only with E/E/PE safety-related measures

Figure 6-7-24 shows an example of application of the risk graph. Tables 6-7-33 and 6-7-34 show risk elements and risk mitigation requirement classes, respectively.

The AFC equipment is allocated to a category of SIL 0, “No safety requirement items,” when estimating its risk following this application example. However, this estimation is introduced here only to show how to use the risk graph with reference to the example. In reality, estimation must be made after reanalyzing risk elements.

[Example in case of the AFC equipment]

i. Result after a dangerous event occurs: A risk of damage at a level relevant to severe injury or death is negligibly small. Damage is inferred to be minor. => C1

ii. Event probability of an undesired event: Except for automatic ticket gates, there is almost no possibility for passengers to be damaged by equipment mechanisms. At automatic ticket gates, there is a fairly high frequency for passing passengers to be blocked by the gates. However, it is thought that a possibility is very low for passengers to fall down when blocked or be hurt when caught by the gates. It is presumed that the possibility is “a little.” ⇒W2

Assuming “i” and “ii” as described above, the risk reduction requirement class is judged to be “*” from the risk graph. Accordingly, “No safety requirement items” is allocated to the AFC equipment.

In analyses as shown in the example, SIL0 is often allocated to the AFC equipment. Then, there will be no need for management, verification, assessment, etc. based on methods specified in Railway RAMS such as IEC 62278. However, they are often applied as a means to manage the AFC equipment status, since they have features that make management easier through indexing the equipment status.

2. Efforts with a focus on human beings

The preceding Section described efforts to make equipment safe and highly reliable; in other word, efforts to realize safe equipment that never fails. This Section introduces efforts with a focus on human beings who operate equipment.

2.1. Regulations related to work safety

Regulations are a basis for performing work safely. In Japan, the following laws are prescribed. In Vietnam, it is necessary to investigate contents of similar laws and identify items that are related to business management of urban railways. After clarifying regulations, business rules and manuals should be developed so as to observe these laws and operate equipment safely.

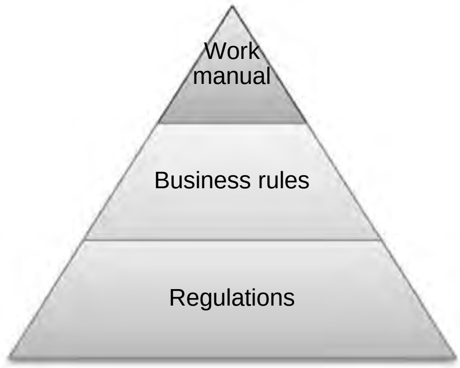


Fig. 6-7-25 Relation among each rule

i. Industrial Safety and Health Act

ii. Order for Enforcement of Industrial Safety and Health Act

iii. Ordinance for Enforcement of the Industrial Safety and Health Act

iv. Labor Standards Act

When applying laws or regulations, business structure should be broken down to each work unit, and a method of confirming existence of applicable laws to each constituent work should be adopted. And then, omission of the application can be prevented.

2.2. How to practice safety management work

Safety management of equipment is required for its safe operation. The most important concept here is that troubles (disasters) never occur to equipment despite risk and hazardous properties, if any, so long as human beings never involved. It can be better understood in the following example: “If a dangerous animal like a tiger exists, there is no risk of being hurt or damaged by the animal so long as a person is not present.” It is significantly different from the efforts with a focus on equipment discussed in the preceding Section, as those efforts do not pay attention to relation between “human beings” and equipment.

(1) System maintenance

Safety management work begins with maintenance of a management system. For this purpose, it is important for the top of an organization to demonstrate clearly his/her determination. It is because safety management needs involvement of all business divisions and these divisions need to proactively participate toward their objectives. In efforts concerning the AFC equipment, it is important to formulate the structure as an organization that can tackle safety management with involvement of all organizations related to the AFC equipment.

(2) Business operation

Business is pursued in the following PDCA cycle.

1) **P**lan

Formulate a plan for safety management including the following items. Related divisions are required to set their objectives and measure their achievement levels.

i. Safety vision

ii. Risk assessment and measures

iii. Objectives and implementation plans

2) **D**o

Implementation and operation. Each division should make an effort toward their objects.

3) **C**heck

Inspection. The achievement levels toward objectives and the methods for making efforts should be inspected and recorded.

4) Action

Measures for improvement. Inspection results should be reviewed and reflected to the formulation of a plan.

2.3. Risk assessment

The core of safety management is risk assessment. Risk assessment is an effort to develop a structure that predicts danger by a systematic method and reduces the danger, without relying on experiences and attention of individuals. Risk assessment consists of the following tasks.

(1) Identification of a target scope

The scope of risk assessment should be defined. For the AFC system, it covers from station facilities such as automatic ticket gates installed in a station to operator servers that are upper level systems. Furthermore, there are a wide range of equipment types and operation locations, including stations, the headquarter office, the settlement division, the maintenance center, etc. It is necessary to define a target scope, such as “equipment operation in stations” or “work in the maintenance center.”

(2) Identification of hazard sources

Hazardous nature and hazardous properties should be identified by breaking down business into work units. In doing so, the following points should be noted.

1) It is necessary to conduct identification work with reference to work manuals and work procedures. If they are not prepared, their documentation is needed by writing down actual work contents for each work unit. This is because hazard sources exist in work manuals and work procedures themselves. Documentation is required to manual work contents to achieve safety assurance without relying on workers.

2) When identifying hazard sources, it must be conducted on the following premises: “Is there any risk in work? Equipment could fail; and human beings could make operation mistakes.”

(3) Estimation of risk

A risk estimation method begins with identification of hazard sources, degrees of damage caused by the hazard sources, and inference of a possibility of accessing or encountering the hazard sources.

1) Category of degrees of damage

Table 6-7-35Division of degrees of damage (Example)

Degree of damage	Category	Guideline
Fatal	×	Death or a permanent physical disorder . Long-term absence from work, or many victims are involved.
Moderate	Δ	Short-term absence from work, or multiple victims are involved.
Mild	○	No absence from work, and a minor injury occurs

2) Category of possibility of accessing or encountering hazard sources

Table 6-7-36 Category of possibility of accessing or encountering hazard sources (Example)

Degree of possibility	Category	Guideline
High	×	Accessing/encountering occurs frequently every day. Getting involved despite of substantial attention.

Possible	△	Accessing/encountering occurs in irregular work such as repair or adjustment of equipment. Getting involved when attention spans are lowered.
Very low	○	No accessing/encountering in regular work. Not getting involved in a normal state.

3) Risk category

Table 6-7-37Risk category (Example)

Degree of risk	Category	Guideline
Unacceptable and grave	III	Grave enough to suspend work till countermeasures are taken. Immediate response should be taken with the highest priority.
To be swiftly reduced	II	It is desirable to suspend work till countermeasures are taken. Response should be taken preferentially.
To be reduced if possible	I	A degree that response is possible or response may as well be taken if it is necessary depending on the situation.

4) Estimation of risk

Table 6-7-38 Estimation of risk (Example)

		Degree of damage		
Possibility of accessing or encountering danger	Category	Fatal	Moderate	Mild
	High	III	III	II
	Possible	III	II	I
	Very low	II	I	I

2.4. Risk reduction measures

Risk reduction measures are taken along with priority decided in estimation of risk. The following approach is a basis for implementation of the measures.

(1) Implementation of items specified in laws
It is a requisite to observe laws.

(2) Essential countermeasures
It is a basis to take essential countermeasures to remove causes of risk, such as elimination of dangerous work.

(3) Engineering countermeasures
These countermeasures mean to take measures on equipment and reduce risk. For example, in order to prevent users from falling down or being caught by the gates of automatic ticket gates, a new method of closing the gates might be introduced, or material of the gates might be changed to a soft type. These measures fall into engineering countermeasures.

(4) Managerial countermeasures

These countermeasures mean to enhance the ability of “human beings” through education and training, or achieve safe work and operation by use of work manuals and workflows without relying on “human ability and experiences.” For example, in handling the AFC equipment, there is work to load a unit with cards in to an automatic ticket machine or retrieve a unit with proceeds from the machine. Cards and money are valuables, and these units are heavy, therefore there may be risks of theft and injury if a unit drops. For this reason, it is necessary to realize safe work (and prevent equipment failure) by preparing work manuals and providing education and training so that work can be carried out in line with the manuals.

(5) Personal protection measures
These measures are intended, even in the worst case, to protect workers when they encounter a danger. For example, according to these measures, workers carrying heavy loads are requested to wear protective footwear and gloves.

2.5. Evaluation of performance

(1) Effects of risk assessment and risk reduction measures should be evaluated to verify whether risk is lowered as intended. Through this verification, adequacy of the risk assessment and the risk reduction measures is confirmed. If risk is not reduced as intended, necessary countermeasures should be taken, and at the same time residual risk should be made widely known to parties concerned.

(2) All of risk assessments, risk reduction measures, and their results must be documented for record keeping purposes. This is for the purpose of accumulating them as formal knowledge for application and avoiding repetition of similar events. To effectively use records, the following points should be noted, in addition to document management provisions of ISO 9001/ISO 9002.

1) Keep records in an identifiable and traceable state.

2) Standardize procedures concerning records.

- Identification of records: forms and record names
- Storage: divisions, places, and persons in charge
- Protection: a rule to prevent damage, taint, degradation and loss
- Confidentiality: confidentiality levels (disclosed, internal use only, confidential, strictly coonfidential) and handling rules

- Search: filing and indexing methods
- Retention period: a rule concerning retention period
- Disposal: a rule on procedures for waste disposal (disposal methods and procedures for approval of disposal)

2.6. Other important efforts

(1) Review by division heads

Division heads should confirm that safety management activities (risk management activities) are properly conducted in their own divisions and these activities are effective. With this confirmation, division heads can grasp, on their own initiatives, details of those activities, and it is confirmed in the divisions that safety management activities are efforts the division heads commit themselves to.

(2) Accident prediction training

In general, there exists residual danger. Accident prediction training is an activity to make staff find, grasp (understand), and solve a danger, so that their sensitivity to danger is enhanced, their ability to solve problems is improved, and that they can prevent occurrence of accidents. In Japan, it is called “Kiken Yochi Training (KYT).” In English, they call it “Accident Prediction Training.” As a well-known implementation method, there is the basic 4 R method where problem solution is tried through the following rounds:

1) Grasping the present situation: What danger hides?

2) Pursuing the nature: This is a point of danger!

3) Establishing countermeasures: What will you do?

4) Target setting: We will do this way.

3 Safety rules

In order to pursue safe work without accidents through standardization of work but without largely relying on individual ability and experiences of “human beings,” it is necessary to prepare documented rules and manuals concerning safety.
An example of a structure of a safety rule considered to be related to the AFC equipment is presented below. Though the AFC equipment is not yet used in Vietnam, it is electromechanical equipment and also E/E/PE equipment. It is important to do the research about laws and safety

rules related to electromechanical equipment and E/E/PE equipment in Vietnam and develop rules and manuals with reference to them.

3.1 General matters

(1) General instruction to staff

Specify the most basic instructions to staff, including orderly disposition (seiri in Japanese [hereinafter the same]), tidying (seiton), cleaning (seiso), cleanliness (seiketsu), and discipline (shitsuke; behavior) that are so-called 5S in Japanese.

(2) Restrictions on engagement

Specify work, such as those requiring qualifications, which staff other than those designated by a head of an organization cannot be engaged in.

(3) Work to accommodate new workers

Specify procedures for allocating new workers to maintenance work and the like. Also include registration and education for safe operation.

(4) Orderly disposition and tidying

Provide specific rules in terms of orderly disposition and tidying in maintenance of workplaces and so on. Also include how to place articles, a means to prevent overturning of high-pressure vessels, sorting and storing of hazardous chemical substances, and so on.

(5) Fire prevention

Include how to handle fire extinguishers, water for firefighting and flammable substances as well as rules concerning smoking and patrols.

(6) Traffic

Include rules concerning traffic such as prohibition of running, temporary stops at exits or turning points, prohibition of passing under loads suspended during work in high places, pointing and calling when crossing a railway track, etc.

(7) Passages

Clarify passage areas and formulate rules of restriction on work in passages.

(8) Clothing

Include clothing rules on wearing uniforms (if any), safety hats, safety footwear, etc. and rules such as prohibition of waring a glove over another.

(9) Protective equipment

Formulate rules to wear protective equipment in high-place work, electric work and jobs in environments with high temperature and big noise. Include safety hats, safety footwear, insulating gloves, light shielding spectacles, dust and gas masks, etc.

(10) Safety devices

Define rules on how to handle safety devices mounted on equipment.

3.2 General work

(1) Work using hand tools

Specify rules on how to handle hammers, spanners, pairs of pliers, and other hand tools. Include bans on the use of tools for purposes other than the original intent, methods of storage, safe methods of using tools, etc.

(2) Work with electric equipment and pneumatic tools

Include safety checks and handling rules of tools using electricity or air pressure as power.

(3) Machine operation

Specify rules related to safe operation of machine equipment, such as designation of operators, wearing protective goggles, inspection at the start and the end of work.

(4) Welding operation

Probably there is no welding operation for the AFC equipment even in maintenance. However, spot welding may be required when repairing a chassis. Formulate rules on welding operation just in case. The rules should cover working clothing, protective tools such as protective goggles and gloves, preparation of fire extinguishers, and ventilation. In addition, as it is hard to expect gas welding and laser welding to be applied to AFC, formulate a rule related to electric welding, such as an operation procedure of electric shock prevention.

(5) Electric work

The AFC equipment is electromechanical equipment and electric work is required very frequently. Accordingly, it is necessary to especially carefully specify rules from the following viewpoints.

1) General work

Specify general rules related to safety, such as a ban on clothing wet or tainted with oil, a necessity to display a sign of “Under Inspection Work” on equipment whose power supply is cut off, and work to be done by qualified persons.

2) Electric equipment

Specify rules on power activation, electric shock prevention, wearing protective equipment, insulation, response to an ignition accident.

3) Switches and power distribution panel

Specify rules on contents to be displayed such as names of persons in charge of the switch box, switch operation, measures to prevent wrong switching operation during an inspection, prohibition of use of fuses that do not meet specifications, and other necessary items.

4) Work under or close to overhead wires

Though it is unlikely that a need arises for work under or close to overhead wires in handling the AFC equipment, there is a possibility that workers come close to overhead wires when moving or carrying equipment. Therefore, rules should be specified on this issue.

- Specify rules to keep the safe distance decided based on voltage to avoid electrification; hold lengthy goods such as a ladder sideways when carrying them under overhead wires; use heavy machinery for construction whose boom height is mechanically limited, and so on. Also specify rules on grounding or use of protective equipment in the case where there is a possibility of electric induction.

5) Work with power outage

Because work with power outage may cause a significant trouble if wrong operation is performed, it is necessary to make a work process clear. Formulate rules on prior notice of a power outage plan to parties concerned in an area to be influenced by the power outage, confirmation of approval (consent), a procedure for voltage check, a grounding procedure, etc.

6) Work around high-tension circuits

Formulate rules on opening and closing of the doors of power distribution panels, wearing protective gloves, cutting off of high-tension circuits, a procedure for applying voltage, control of entry to a working area during work-in-progress, etc.

(6) Painting operation

It is rare that painting operation is required for the AFC equipment. However, there may be a case where painting is required on a chassis that has damage caused in maintenance work. Specify rules on exhaust ventilation, prevention of catching fire and solvent inhalation, measures for splash prevention of paint waste and coating material.

(7) Crane operation

There may be a possibility of operating crane when moving or carrying heavy loads. Formulate rules such that crane operation should be carried out by qualified persons, and specify other rules on crane’s rated load, crane’s operating radius, prevention of contact with overhead wires, protection of overhead wires, and arrangement of staff to keep watch on trains in the case of operation in the proximity to a track.

(8) Slinging work

Slinging work is for suspending a heavy load from the hook of a crane. In Japan, the Industrial Safety and Health Act specifies that slinging work with 1 ton or more of a load must be done by workers who have completed the skill training course. Specify rules on outfits such as safety hats, whistles, and hand flags, weight of lifted loads and rated load, sling angles, ropes used in a method with two or more hanging ropes, how to exchange signs with a crane operator and other work procedures.

(9) Handling of heavy loads

In order to handle heavy loads safely, specify rules on use of appropriate transporting machine, a necessity for two or more workers to be engaged, use of the word as signs to others, working postures, procedures for loading and unloading, etc.

(10) Operation of forklifts

In Japan, the Industrial Safety and Health Act specifies that operation of forklifts is allowed only for those who completed the skill training course for forklift operation and the operation special training. Here, specify rules on safety operation, including prevention of uneven loading, operation at the time of operator’s leaving the seat, compliance with limit load, running speed, fork operation, etc.

(11) Operation of business automobiles

Formulate rules on general instructions concerning safe driving of vehicles. Specify rules on brakes and lights, rear-view mirrors, tire pressure, the amount of fuel remaining, superimposed load, uneven loading, check of speed limits, a ban on one-hand driving, moving at a crawl, and other matters related to driving operation.

(12) High-place work

Work at the height of about 2 meters or more is regarded as high-place work. Specify rules on high-place work, including methods to secure safety and work procedures. Accidents happen in high-place work more often than in other types of work. Therefore, safety should be assured by specifying work procedures in a detailed manner. Specify rules on methods of laying out the framework, wearing safety belts, stepladder operation procedures, etc.

(13) Operation of vehicles for high-place work

In Japan, the Industrial Safety and Health Act specifies that driving of vehicles for work at height is allowed only for those who completed the skill training course. To be specific, a vehicle for high-place work means a service vehicle whose working floor is 10 meters high or more. As for the AFC equipment, it looks like quite rare to conduct high-place work of more than 10 meters. However, there can be a case where such work is required when moving equipment from an elevated station. So, it is better to specify such rules. Specify rules on making work plans, installation of supervisors, wearing safety belts, clear indication of work areas and entry control, the out-trigger mechanism to make a service vehicle stable, the withstand load, electric shock prevention measures in case of work in the proximity of overhead wires, etc.

(14) Safety equipment at opening sections

Opening sections mean ports for lifting and lowering materials and the like. Specification of rules on related work procedures is necessary because prevention of accidental fall by use of safety equipment is required. The rules should be include installation of handrails at the whole circumferences of opening sections during work, display of “No Entry” signs at unused opening sections, installation of covers and safety net devices, wearing safety belts during work, use of hooked rods when taking in loads, etc.

(15) Drilling and chipping work

For the AFC equipment, this work is not conducted in ordinary time. However, when installing new equipment or replacing old equipment, this work is required in laying power cables or communication wires under the floor. Rules are required to be specified, since there is a possibility of injury on human eyes with scraps flying apart or damage on buried objects if drilling and chipping are conducted without enough care. Specify rules on wearing protective gloves and goggles, a prior check on buried objects, a check on tools, and safe operation methods.

(16) Pipe processing work

For the AFC equipment, this work is required when laying down pipes for installing or relocating power cables and communication wires. When performing threading at a connection part between a metallic pipe and a joint, chips might fly apart and harm human eyes. Furthermore, when connecting a metallic pipe with a joint, a wrench might spin around vainly by mistake, causing injury on the human body. Therefore, it is necessary to specify rules on work procedures. Specify rules on use of protective goggles and suitable tools.

(17) Transport work

As transportation work is conducted frequently, rules should be specified on work procedures in a specific and detailed manner. Specify rules on a need to lock wheels of a lorry on loading and unloading, a right method of handling freight, a right posture to avoid hurting a back when manually carrying freight, a right method of driving a power lorry, etc. Especially, formulate a rule such that a lorry equipped with a stopper or a brake should be used when using it on the platform.

(18) Cleaning work

Cleaning is work to be conducted to wash out a stain from parts mainly when performing overhaul maintenance of the AFC equipment. Specify rules on instructions on wearing protective gloves and goggles and ventilation, rules on safe handling of cleaning fluid in chemical cleaning and in cleaning with gasoline or light oil, a check on the injection tip and washing apparatuses in the case of vapor washing or high-pressure jet washing, etc.

3.3 Maintenance work

(1) Common matters

1) Communicate in advance with stations where the AFC equipment is used, a data center of each line, the data center of the operating company, education and training centers, the IC card issuing center, etc. and ask them to send persons in charge of handling the equipment before and after maintenance work.

2) Display a sign such as “Under Maintenance” on the control panel of a power distribution panel during work so as to avoid operation by mistake.

3) Do not touch movable parts during operation of equipment.

4) When there are two or more pieces of equipment in use, perform maintenance

with confirmation of target machines for maintenance with reference to specifications and a maintenance plan.

5) Qualified persons should be made engaged in work, and safety precaution should be intensively observed.

6) When performing collaborative work, it should be observed that switching operation such as power activation is done only after checking actual response from the other party.

7) When inspection is completed, equipment should be delivered after their functions are checked.

(2) Inspection of ticketing work

1) Display signs such as “Under Adjustment” or “At Work” during work.

2) Put a workplace in order and tidy it up.

3) Take note of tool boxes and materials around automatic ticket gates so that they never obstruct passage of people.

4) Do not put objects such as hardware that might fall on automatic ticket vending machines or charging machines.

5) Before starting work, check whether there are fallen objects, and, if any, remove them and then start work.

6) When installing or removing a unit, first check whether the power supply is ON or OFF.

7) When carrying a heavy load such as a unit, a number of workers enough to handle the weight and the shape of the load should be engaged in the work.

8) When a worker moves during work, he should first check the surrounding before moving.

3.4 Work on commercial lines

Workers never come in the proximity of a commercial line because the AFC equipment is installed at a point distant from the platform even when it is used as station service equipment. However, there is no denying that equipment is carried over a commercial line for maintenance work, or workers come in the proximity of a commercial line when they conduct wiring work with power cables or communication wires. Therefore, rules on work in the proximity of a commercial line should be specified. The rules are not unique to the AFC equipment, but their particulars are common to the overall work to be done in the proximity of a commercial line. Accordingly, they should be subject to the standard rule on commercial line construction and operational safety that is expected to be specified for maintenance of track.

(1) General rules

1) Apply the standard rule on commercial line construction and operational safety (confirmation required)

2) Confirm clearance gauge.

This gauge means a range where building structures that can be an obstacle to operation of trains are not allowed to be situated, whether or not they are movable. If a worker enters this range, it can directly lead to an accident with a train, so it is important to make this gauge completely known to all the parties concerned.

3) Make a construction line section completely known to all the parties concerned.

4) Make a place for temporarily storing materials completely known to all the parties concerned.

5) Thorough implementation of trace confirmation after completion of work

”Trace confirmation” means a check to be made after completion of maintenance work and the like. It means to check whether or not instruments or tools are left behind after completion of work.

(2) Allocation and duties of construction workers

Specify rules on allocation and duties of workers required for work (construction), as specified below. Only qualified persons can be engaged in the following work assignments.

1) Supervisor

The supervisor should be in charge of implementation management and personnel allocation in the worksite.

2) Trace confirmation personnel

The trace confirmation personnel is in charge of confirmation after completion of work. If a lorry or the like left behind is within clearance gauge, it might be hit by a train, resulting in a big accident.

3) Person in charge of line closing

Line closing means to stop trains from coming into a construction line section to ensure safe work. A person in charge of line closing should perform line closing, a check on trains, etc. If there is a mistake in line closing, a big accident, such as an accident resulting in injury or death, might happen. Therefore, a person in charge of line closing should follow specified procedures to apply and obtain approval for line closing. He should also grasp train operation status during line closing.

4) Train picket

A train picket is in charge of keeping guard against trains during construction work. When trains are approaching, he should give signs according to procedures which are separately specified.

5) Conductor

When using heavy machinery for construction, vehicles for construction, and road-rail vehicles, a conductor should be allocated so that these vehicles can run safely in the construction area.

(3) Plan for measures to prevent accidents

Specify rules on implementation plans of safety measures (safety equipment, allocation of security staff, etc.) for construction work, a security confirmation document for checking qualifications of security-related staff, security meeting sheets used to get permission from safety inspectors in terms of daily work details, and other work procedures.

(4) Implementation of measures to prevent accidents

Specify rules on staff allocation, wearing protective devices, operation, tools, work attitudes and others in specific implementation of plans for measures to prevent accidents. These rules should include items such as roll calls, a method to issue work instructions, pointing and calling, a ban on use of metallic ladders, trace confirmation of brought-in tools, and so on.

(5) Measures to be taken in adverse weather

When adverse weather happens with strong wind, heavy rainfall, etc., it might be possible that an event that is never observed in normal time happens, including inundation, a flood, rolling motion of equipment. Therefore, specify rules on items to check, a contact system, and other matters needed in times of adverse weather.

(6) Third party disaster and accident prevention

For the AFC equipment, third parties mean in most cases its users. In order to prevent users from coming into the work area, specify rules on arrangement of conductors, use of protective sheets for partition at the work area, display of signs such as “No Entry.”

3.5 First-aid treatment

When an injury accident happens, first-aid treatment would be required after quickly rescuing a sufferer till a medical doctor arrives. Accordingly, rules and procedures should be specified on first-aid treatment. Their specific details need to be decided with reference to emergency medical measures practiced in Vietnam.

3.6 Others

(1) Standards of wearing protective equipment

Specify rules on wearing protective equipment so as not to rely on judgment by individuals.

Table 6-7-39 Standards of wearing protective equipment (Example)

<table>
<tr><th></th><th>Type</th><th>Scope of application</th></tr>
<tr><td rowspan="2">Hat/Cap</td><td>Helmet</td><td>Overall work area</td></tr>
<tr><td>Cloth cap</td><td>Locations where wearing a helmet can be avoided.</td></tr>
<tr><td rowspan="3">Spectacles</td><td>Protective goggles</td><td>Overall work area</td></tr>
<tr><td>Face guard</td><td>Work where dust is generated such as grinding.
Work requiring a posture facing upward.</td></tr>
<tr><td>Light shielding glasses</td><td>Welding, etc.</td></tr>
<tr><td colspan="2">Earplug</td><td>Work accompanied by big noise.</td></tr>
<tr><td rowspan="2">Mask</td><td>Dust mask</td><td>Work where dust is generated such as grinding.</td></tr>
<tr><td>Gas mask</td><td>Work using hazardous chemicals such as organic solvent.</td></tr>
<tr><td rowspan="4">Glove</td><td>Rubber/vinyl gloves</td><td>Cleaning work handling chemical substances</td></tr>
<tr><td>Rubber insulated gloves</td><td>Hot-line jobs (in a state of electric current flowing)</td></tr>
<tr><td>Cut wound -preventing gloves</td><td>Work with cutting tools.</td></tr>
<tr><td>Cloth/leather gloves</td><td>Work to handle heavy loads.
Work to fully fasten a union of piping or the like.</td></tr>
<tr><td colspan="2">Safety belt</td><td>High-place work</td></tr>
<tr><td colspan="2">Hood
Apron foot cover</td><td>Welding</td></tr>
<tr><td colspan="2">Leggings</td><td>Work in the proximity of a track.
Work in a narrow place with protrusions</td></tr>
<tr><td>Shoes</td><td>Protective</td><td>Overall work area</td></tr>
</table>

	safety shoes	
	Laced long boots	Hot-line jobs. Work in the proximity of a track.
	Safety rubber boots	Work with water.

(2) Safety colors/safety signs

Safety colors/safety signs are measures to indicate the meaning related to danger, caution, fire protection, etc. by use of colors and signs. They are characteristic in that they can be instantly identified visually, so that they are used in various cases. ISO 3864 (Graphical symbols - Safety colors and safety signs) specifies colors and signs to be used, so that it is desirable to conform to this standard.

(3) Communication method in unusual situations

In order to make a prompt and appropriate response possible in case of an unusual situation, rules should be specified on the following items, and parties concerned should master them through training that should be conducted in normal time.

1) Setup of an emergency contact network

When an accident or any other disaster occurs, information must be quickly distributed to divisions concerned, and action must be taken following appropriate instructions. For this purpose, it is necessary to define contact procedures in case of occurrence of an accident.

- Contact information
- Contact rule (who calls whom)

2) Standardization of messages to be communicated

Confusion is usually generated in emergency situations, so necessary information might not be distributed properly. For this reason, it is helpful to define minimum required contents of information to be distributed.

4. Response on the Outbreak of an Accident

4.1. Features of the AFC equipment

The AFC equipment needs to function from the start of business in the early morning to the end of business late at night without interruption. Furthermore, the data centers of OU and HMC should complete processing of fare data and other data of the day, so that they must work after the end of business over the midnight. Therefore, there is a need for a system that can promptly respond to a situation and restore equipment if an accident should occur where a failure of equipment causes it to

stop.
The AFC equipment is a network system that processes data through connection to a network. Therefore, a trouble might have a significant influence depending on its cause. If a large-scale accident should occur, an ordinary maintenance system cannot cope with the situation. For this reason, there is a need for a scheme to respond to a large-scale accident, including provisions about an emergency contact network, members to be mobilized, procedures of calling them, etc.
AFC machines placed in stations are dispersed through an urban area stretching over tens of kilometers. It means that there is a possibility that maintenance staff cannot promptly arrive at a station where an accident has broken out. Therefore, there is a need to set up a system, including a base for maintenance services in each section.

4.2. Accident response system

In order to build a system where requirements characteristic to the AFC equipment are reflected, it is necessary to define organizations and their roles. Table 6-7-40 presents an example of organizational structure. The on call center, where information is consolidated and response is controlled, plays a key role. It is also important, when a large-scale accident occurs, to provisionally set up countermeasure headquarters where authorities and functions should be concentrated so as to handle the situation promptly.
Now, it is necessary to review how the on call center is positioned. In the urban railway of Hanoi City, HMC is in charge of implementing headquarters functions, and OU performs business operation for each line. From this standpoint, the on call center can be regarded as an organization that belongs to OU. However, with a focus on a necessity to integrally handle accidents in all the lines, it is better to position it as a division that controls all the lines. It seems to be a practical approach to first set up an on call center in each line, and integrate them in the future.

Table 6-7-40 Organizational structure (Example)

Division	Function
Station (with equipment for station operation installed)	Activate an alarm on accidents or failures.
OU (with a train line server installed)	
HMC (with a business operator server installed)	
On call center (*)	Monitor and control accident/failure information.
Division of OU in charge of the AFC equipment	Recover and repair equipment after accidents or failures.
Equipment maintenance service company	
Division of HMC in charge of the AFC equipment	Supervise accident/failure recovery countermeasures.
Countermeasures headquarters (a provisional organization)	

(*) In Appendix 8-6-7-1 (A)-D, it is expressed as “maintenance control division.”

4.3. Workflow of accident response

It is desirable to take countermeasures according to details and scales of an accident. For this purpose, it is necessary to make clear judgment criteria and persons in charge of judgment. An example is presented below.

- Common accidents (small-scale observed in specific equipment at a specific location, etc.)
- Serious accidents (large-scale, unrecoverable, related to injury or death of human being, etc.)

(1) Common accidents

Common accidents are handled within an ordinary organizational system. As the equipment division of the headquarters office does not directly handle these accidents, their roles are not specified in the accident recovery workflow. However, as part of technical management work, the division needs to give guidance while receiving reports, in the form of weekly, monthly and yearly reports, on maintenance from the OU equipment division. Figure 6-7-26 shows one example, but the flow should be developed taking into account official capacity of OU and HMC.

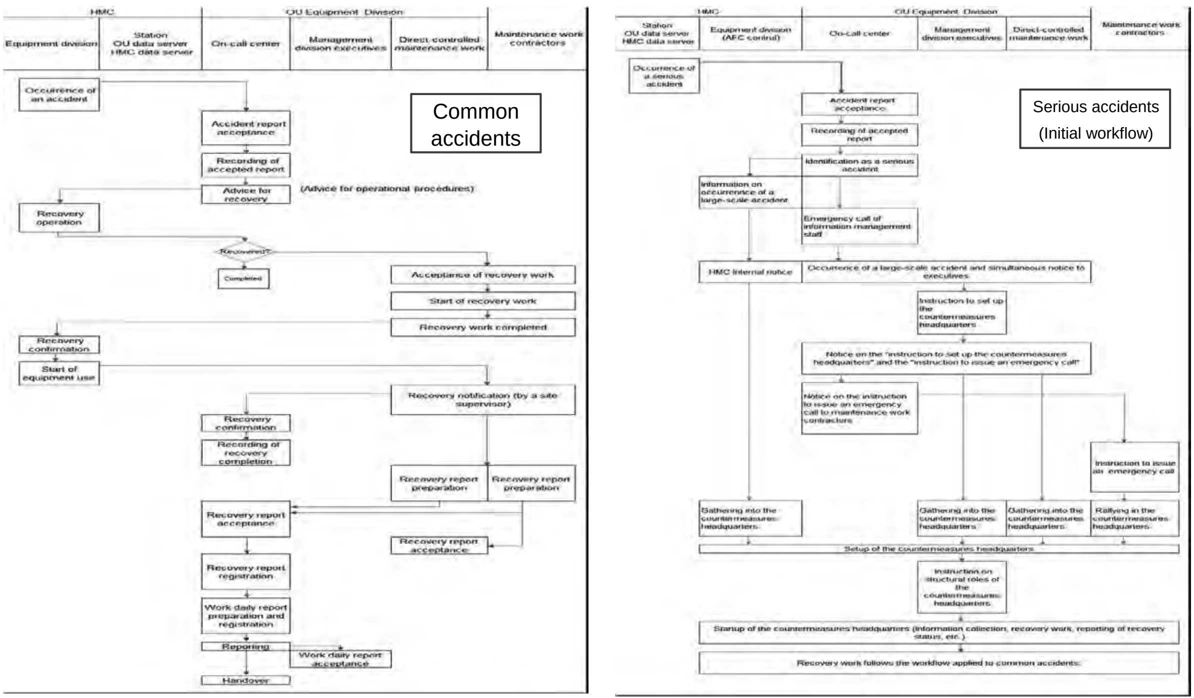


Fig. 6-7-26 Accident recovery workflow (Example)

(2) Serious accidents

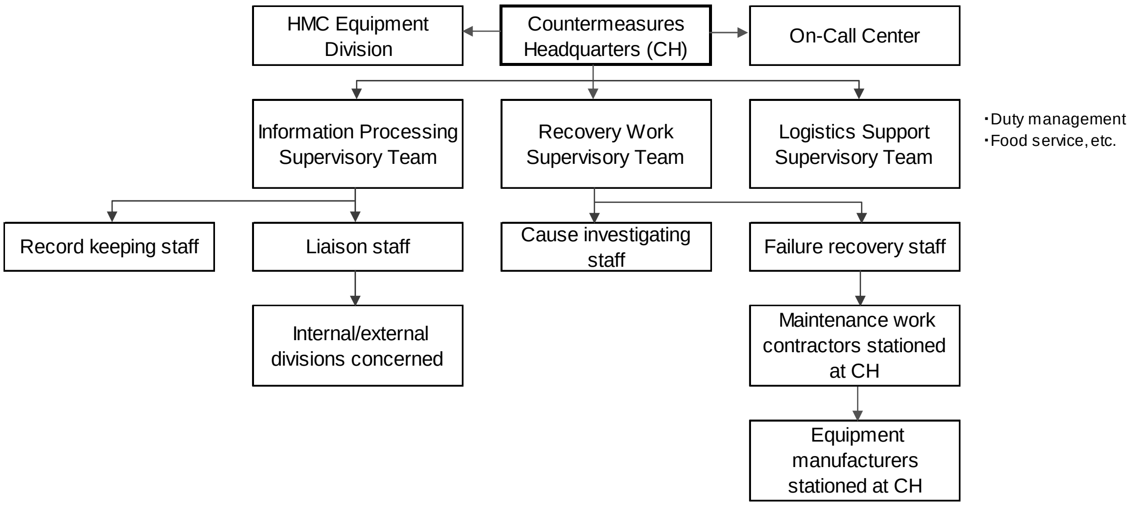


Fig. 6-7-27 Structure of countermeasures headquarters (Example)

In serious accidents, information should be quickly distributed to corporate executives, divisions concerned, and other various parties concerned. In this regard, a scheme of emergency contact becomes one of key issues.

In addition, it will be an effective measure to set up a provisionary organization such as countermeasures headquarters where information and command authority are concentrated, in order to lead various parties and divisions concerned and carry out recovery work swiftly while avoiding confusion about information and command.

In serious accidents, the first motion after obtaining accident information is very important. Clear workflow is needed for building organizational structure to achieve swift recovery.

Cause investigation of serious accidents is also very important in order to make causes clear and prevent recurrence of accidents. In addition, recovery work is sometimes carried out around the clock, so that duty management of staff, food services and other related matters should be taken into consideration. Figure 6-7-27 is an example of the structure of countermeasures headquarters.

Appendix 8-6-7-5-A(A) Collection of Rules for the Maintenance of the Equipment Used for Line 2A

1. Information obtained from TECHNICAL DESIGN
   Sources: TECHNICAL DESIGN, Package 5 EPC CONTRACT, BOOK 5 Equipment System, Volume 10 Automatic Fare Collection System (AFC)
   No. HNHD-05-10-00-00-TDS-C

   (1) Design guidelines and important technical indicators
   (2) Equipment and devices constituting AFC systems
   (3) Management and operation methods of electronic train tickets
   (4) System structures for AFC processing
   (5) Functions and operational management of AFC systems and equipment
   (6) System for performing maintenance work
   (7) Education and training systems
   (8) Data processing network systems
   (9) Electric power supply and grounding
   (10) Equipment allocation
   (11) Facility spaces
   (12) System interfaces
   (13) Analysis on localization
   (14) Estimation of the number of equipment and devices

   Items (6) and (7) above have some descriptions of maintenance

   (6) System for performing maintenance work
   The concept that the line district center has the central control function of AFC and issues instructions to take measures for abnormality as mentioned below. It is close to that of this chapter.
     1) The line district center of Line 2A takes central control of AFC equipment and systems.
     2) In a similar way, the center takes center control of updating and down loading equipment software

   (7) Education and training systems
   It is described to establish an education and training system in the maintenance center. The organization name listed in the staff allocation table of Line 2A is Electric Signal Communications Maintenance Department. There is a difference.

Key Issues for the Urban Railway in Hanoi

Seminar for the HMC Railway O&M Company

In Hanoi,

1st August, 2013

Prof. Dr. Shigeru MORICHI

Director, Policy Research Center

National Graduate Institute for Policy Studies (GRIPS)

Adviser, Hanoi Metro Project

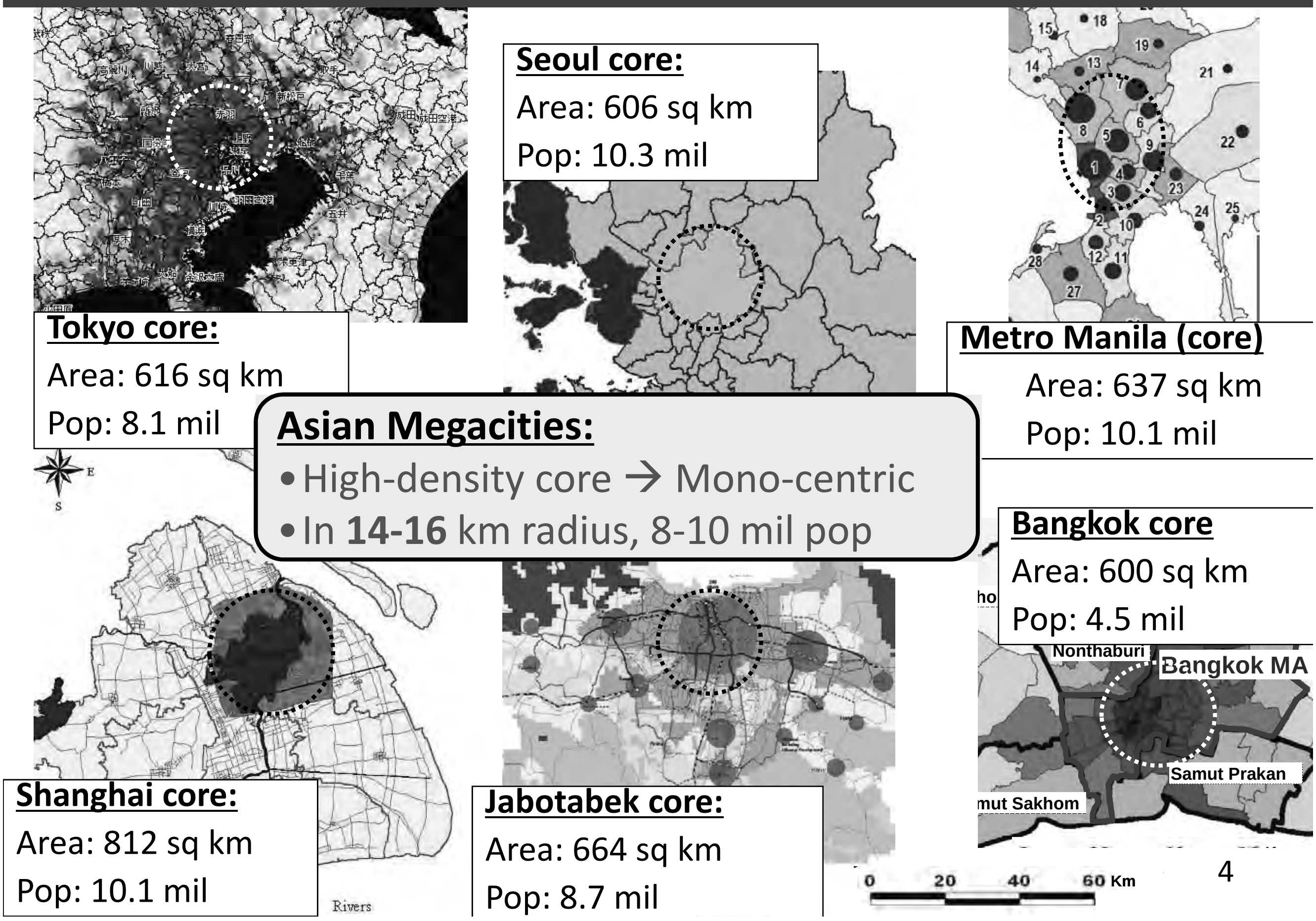
Contents

1. Introduction

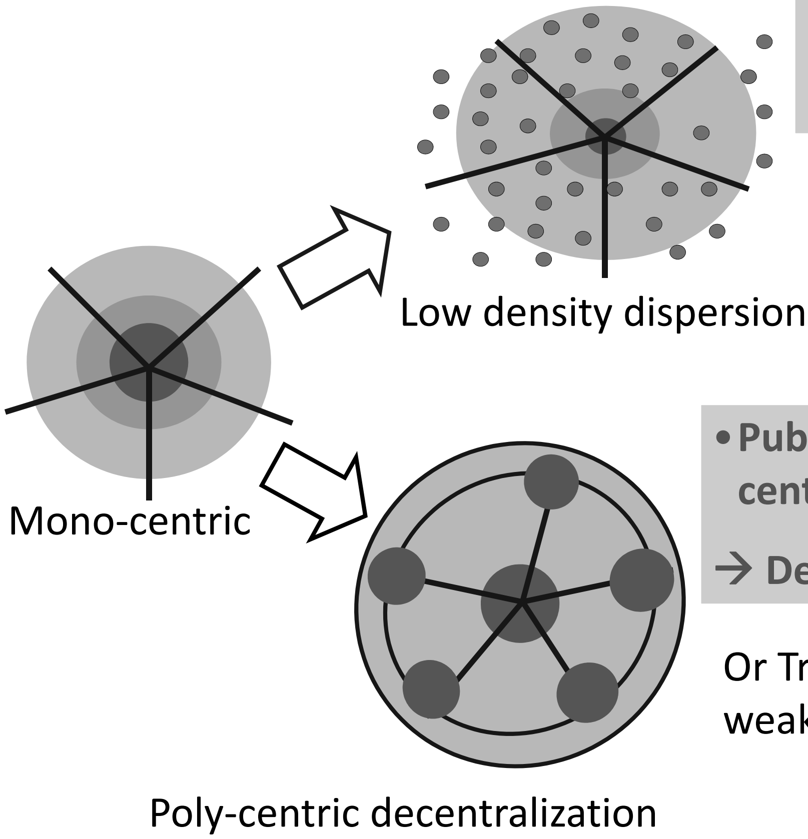
- Specialty of Transport in the Asian Megacities -

- Asian megacities are different from European and US cities.
  : Size of population and urbanized area
  : Increasing speed of population and motorization
- Railway oriented urban structure is desirable.
- Coordination between urban development and railway, and timing of development are necessary.
- Profitability of railway operator is required.

① Urban Structure and Transport: Mono-centric urban form



Population Decentralization: possible spatial patterns



- Car-oriented sprawl

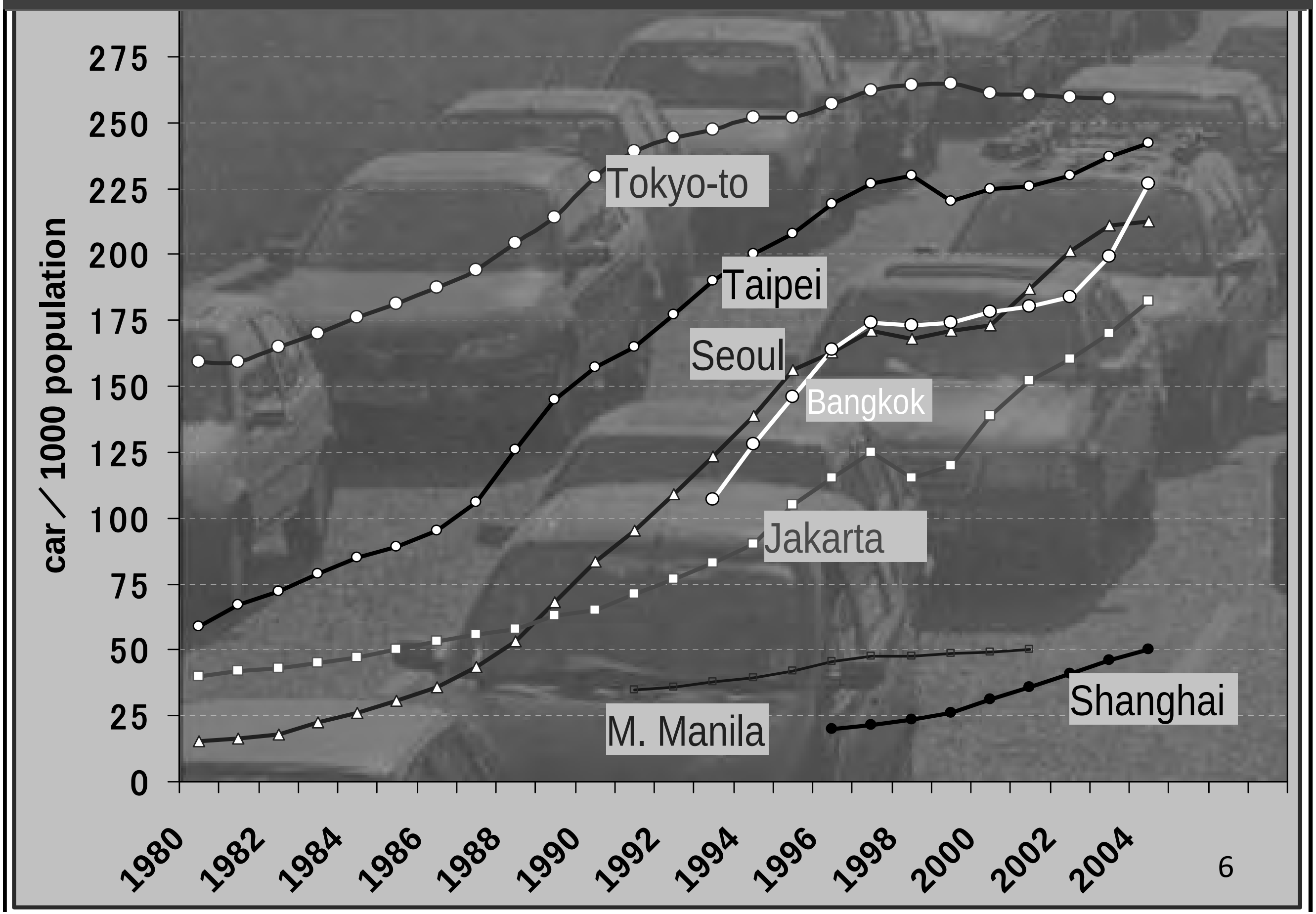
→ Undesirable !

- Public-transport oriented poly-centric form

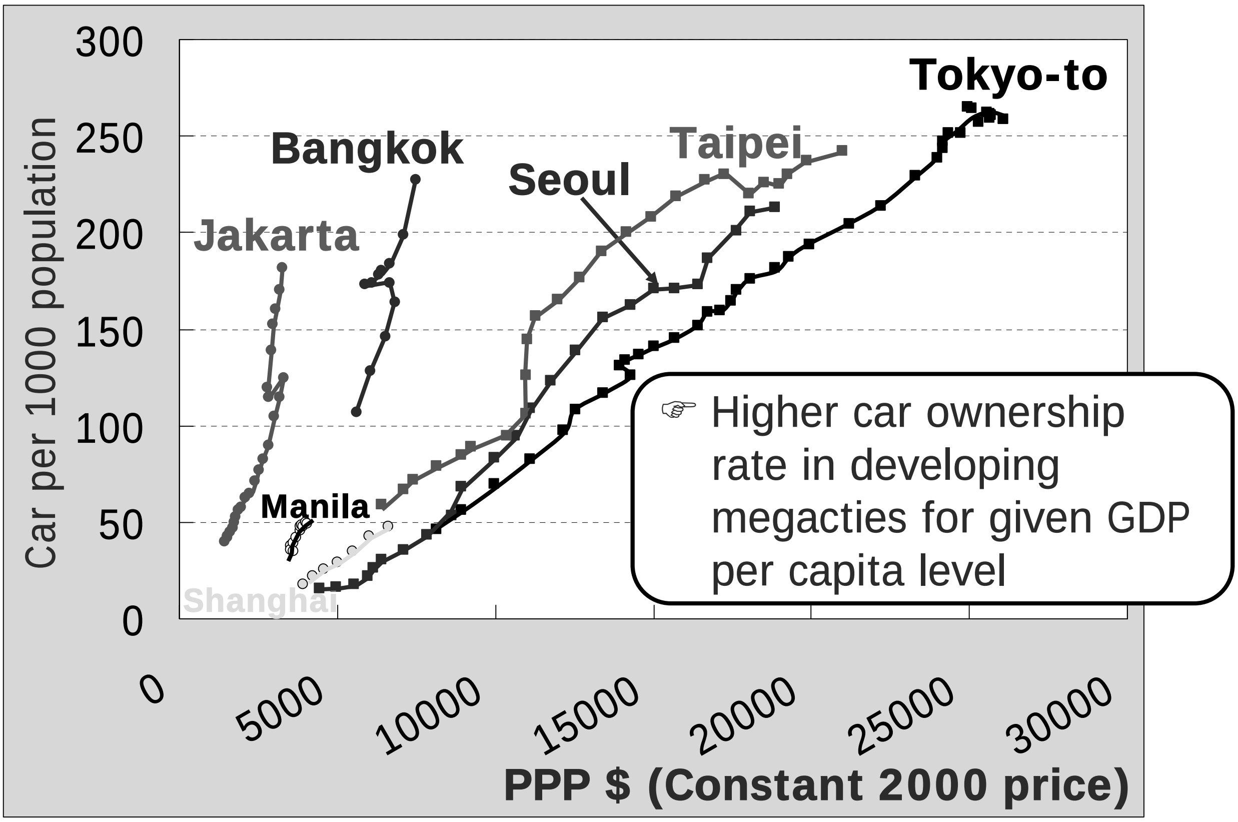
→ Desirable!

Or Transit corridor with weak centers

② Car Ownership and Road Transport

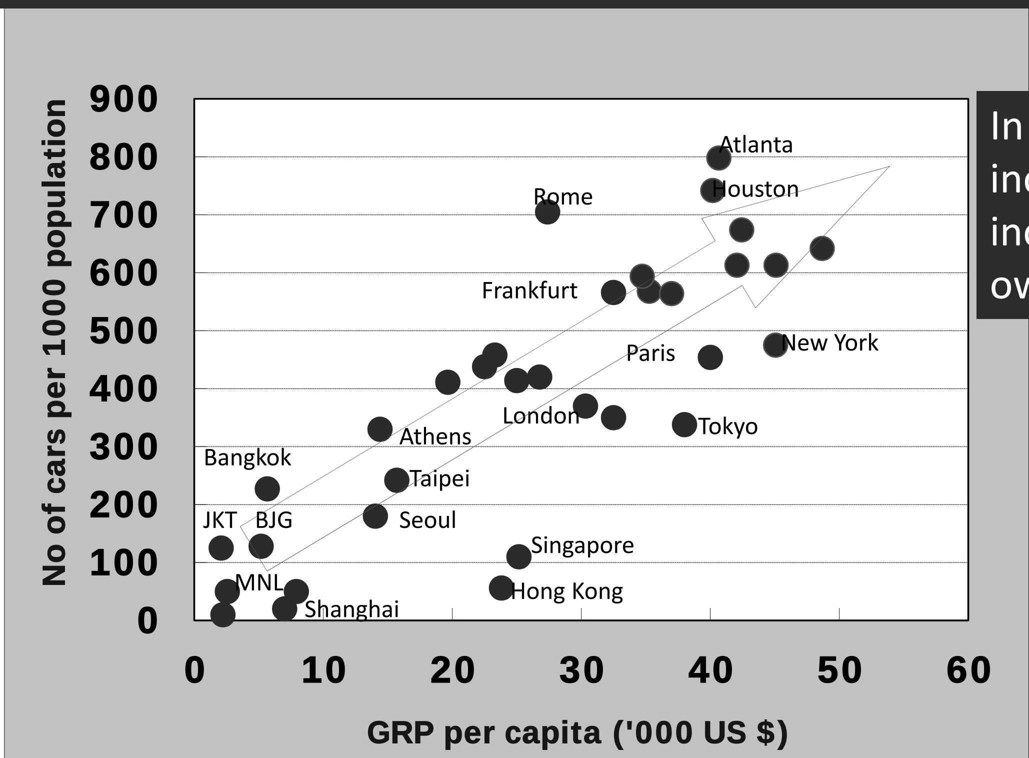


GDP per capita and city-level car ownership rate



GRP per capita Vs car ownership rate:

Selected metropolitan areas (2002~04)



In general, income growth increases car ownership rate

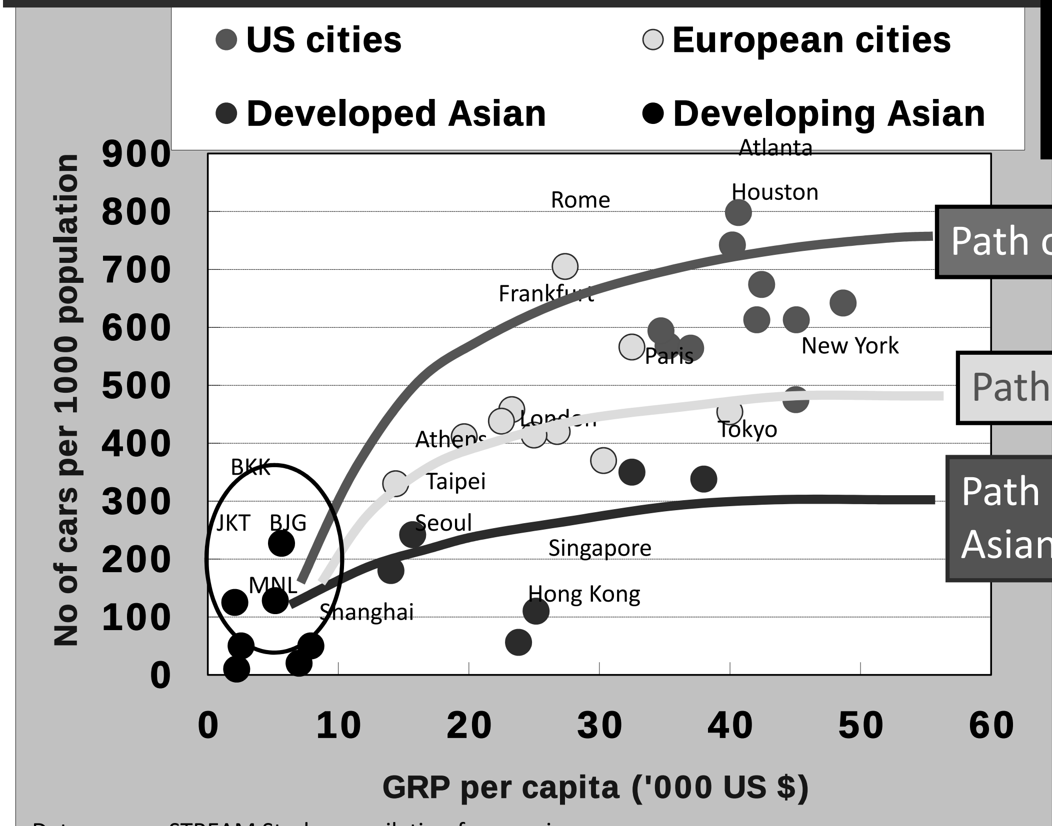
Data source: STREAM Study compilation from various sources

GRP per capita Vs car ownership rate:

Selected metropolitan areas (2002~04)

Alternative paths for Asian Dev'ping cities?

Different patterns by regions!



Data source: STREAM Study compilation from various sources

Path of US cities?

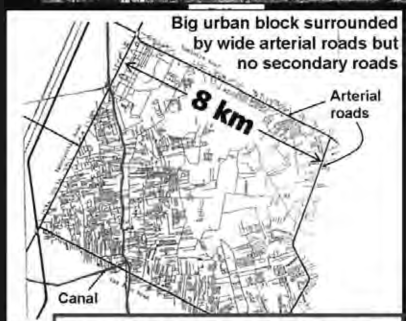
Path of EU cities?

Path of developed Asian cities?

Road Space in Selected Cities 2004

	Area (Km2)	Pop. Density Per/ha	Road Area Km2	Road Area % (city area)
City of Paris	105	202	27	**25.8**
New York City	678	112	210	**25.2**
Inner London (12 boroughs)	589	72	96	**16.4**
Inner Tokyo (8 wards)	110	121	24	**21.7**
Tokyo 23-wards	621	131	114	**18.1**
Seoul City	605	168	80	**13.3**
Taipei City Inner Core	134	197	20	**14.9**
Shanghai City Inner Core	108	378	13	**12.0**
Bangkok City Core	225	96	16	**7.2**
Jakarta City	656	133	48	**7.3**

Data source: STREAM Study compilation

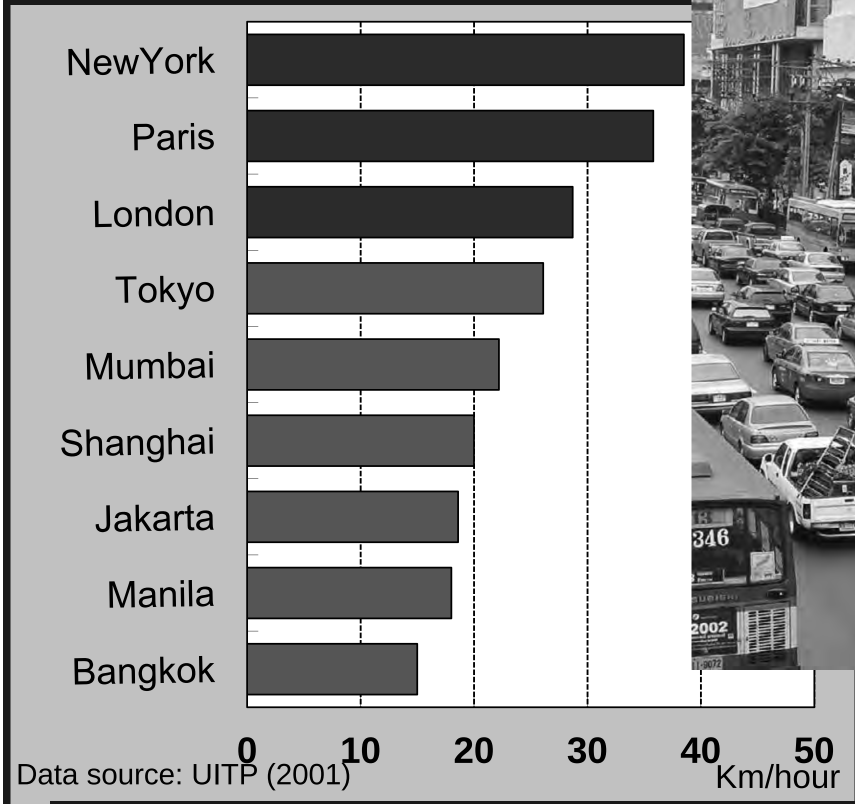


An urban block in central Bangkok

Asian Megacities

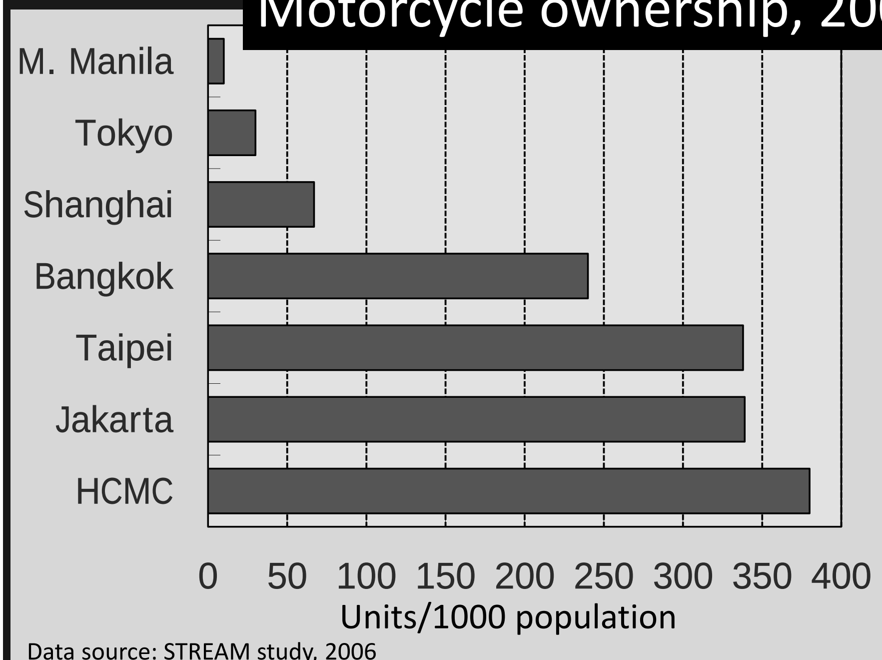
- In adequate road
- Inefficient road hierarchy

Average Speed of Road Traffic



☞**Result → severe traffic congestion !**

Motorcycle ownership, 2004

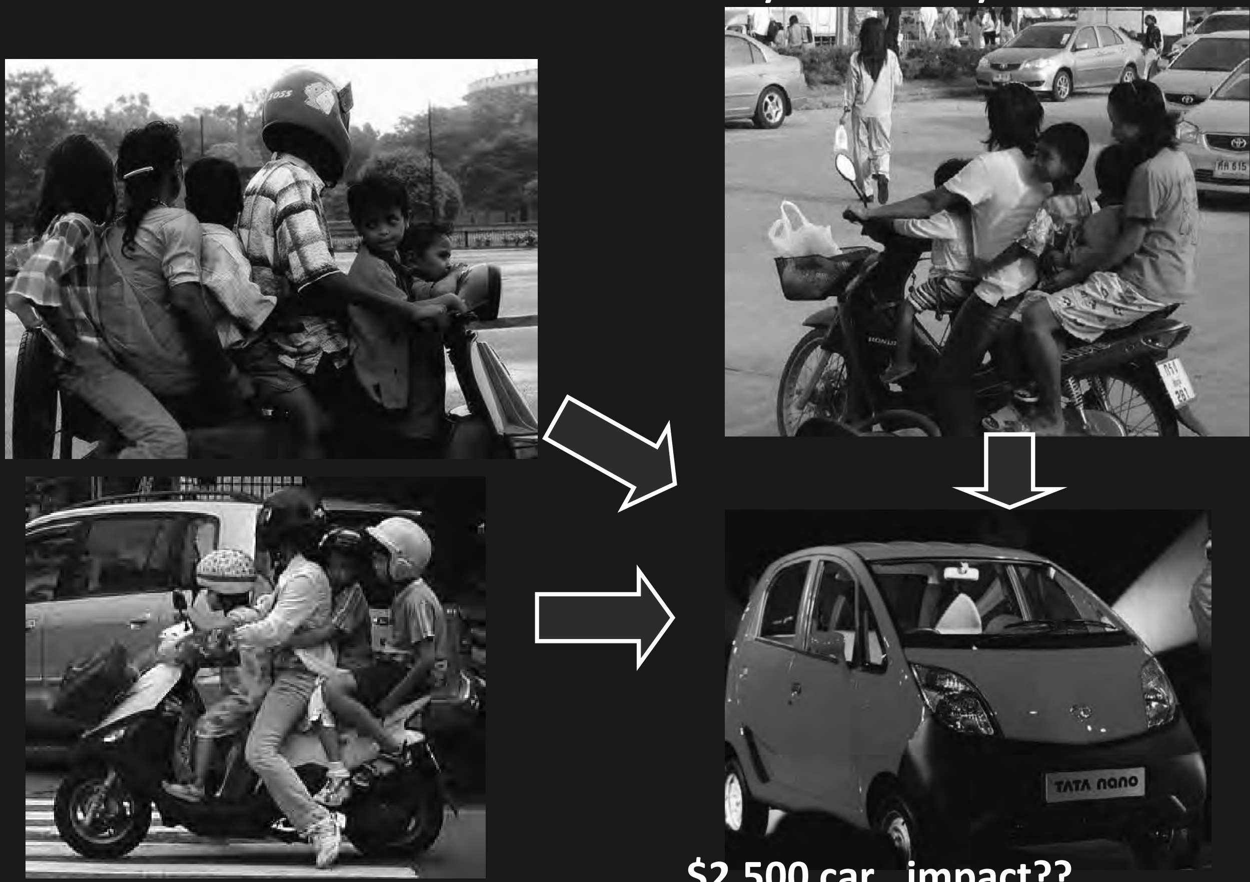


Rapid growth in motorcycle ownership

Pressure of motorization at early stage

Impact on environment and safety

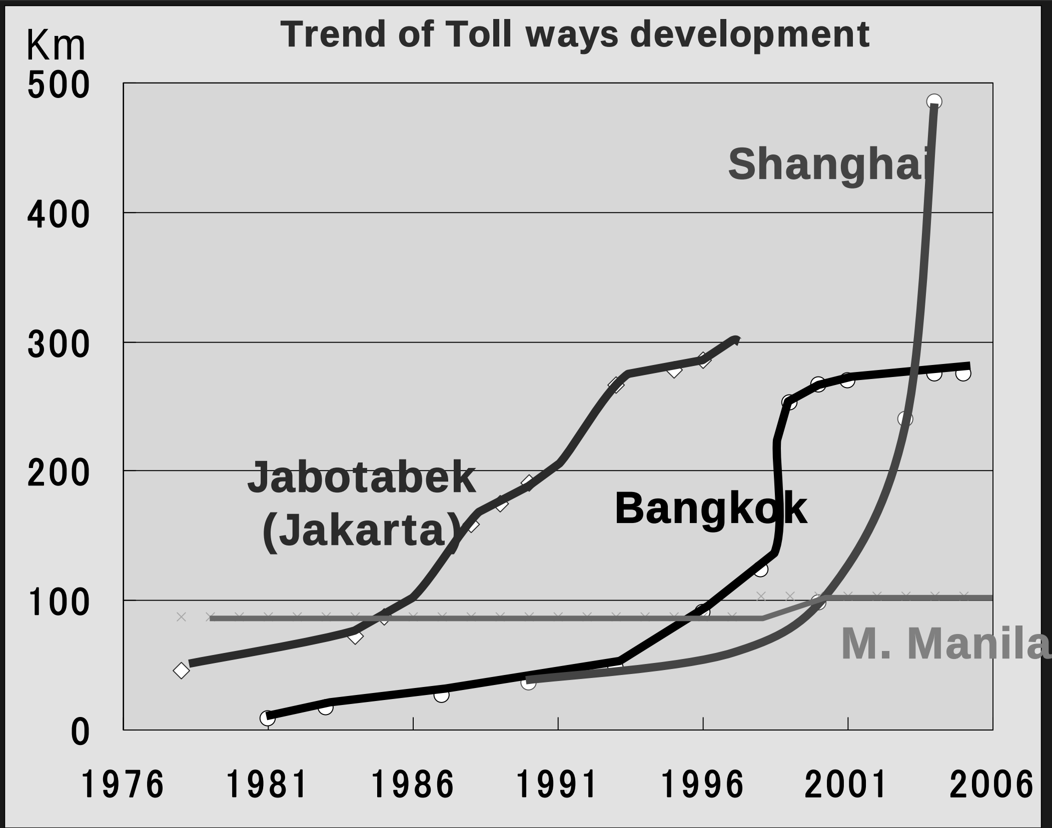
TATA nano: alternative to “family motorcycle” in Asia



$2,500 car…impact??

Policy Response to Congestion → Build Expressway?

Some cities have developed Toll ways rapidly…

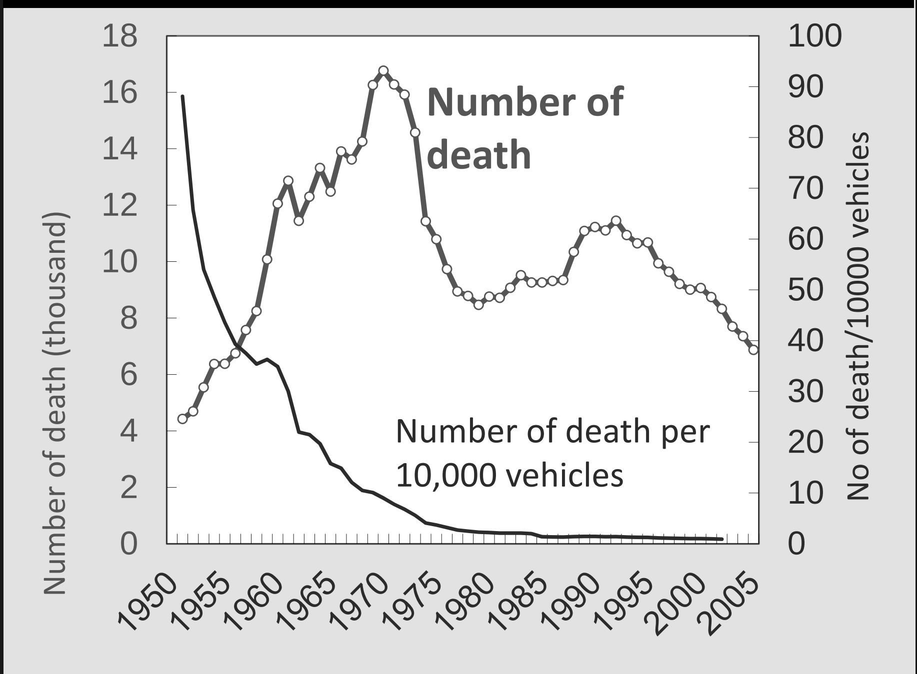


Data source: STREAM Study compilation

…any better alternative?

Under rapid motorization challenging accident dynamics

Trend of road traffic accident death in Japan

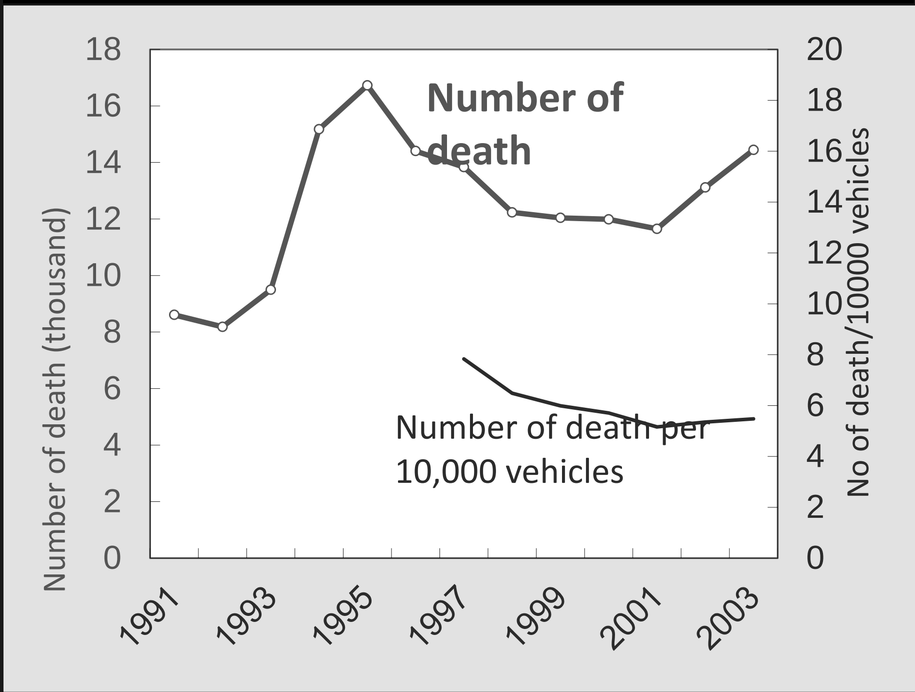


Source: Bureau of Statistics, Japan

- How to avoid the peaking of fatalities?
- Possibility of stabilizing total fatalities earlier?

Thailand: following Japanese pattern?

Trend of road traffic accident in Thailand



Data source: National Office of Statistics, Thailand

Notes:

- Motorcycles included in vehicles pop
- Vehicle population over-estimate
- Is it possible to achieve Japanese rate of <1 death per 10000 vehicles?

Directions for the future

Road oriented: Los Angeles

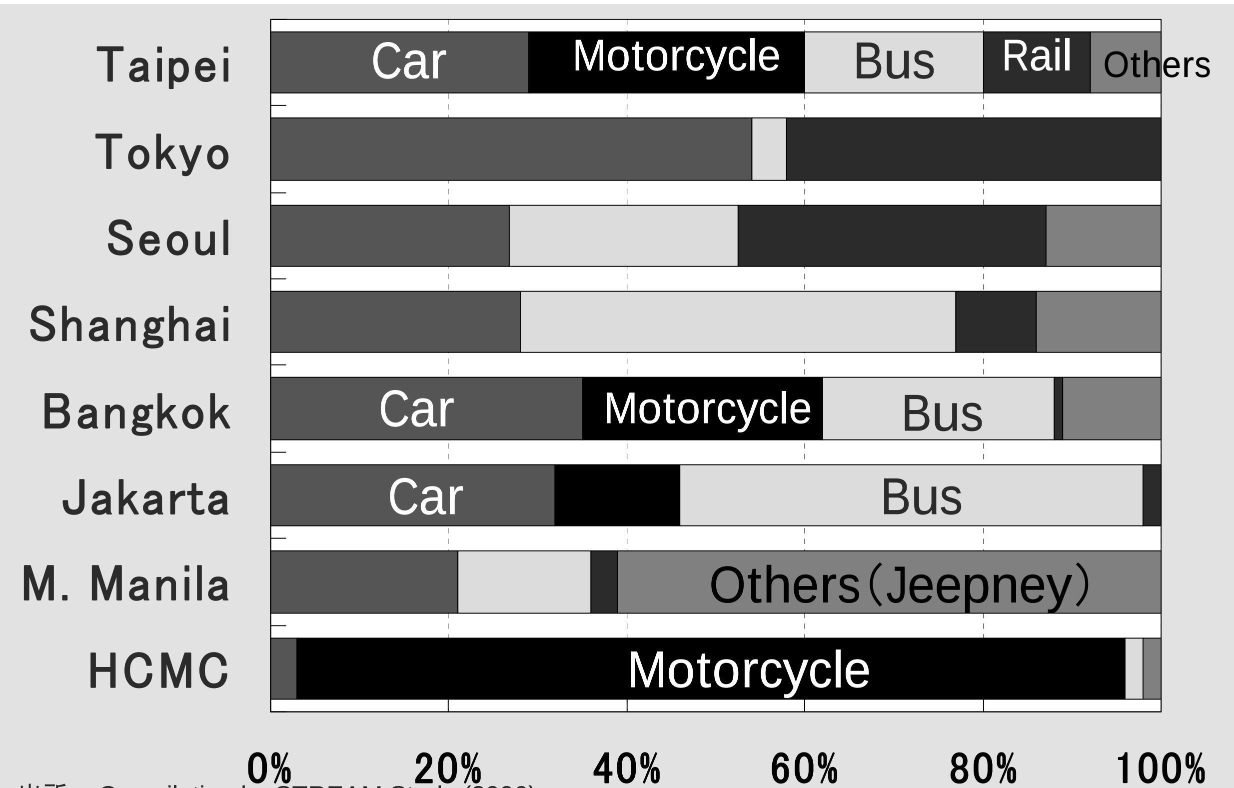
Rail oriented: Tokyo

③　Public Transport

- Toward better transport service that is..
  - Accessible and Efficient (Economically efficient)
  - Clean and healthy (Environmentally sound)
  - Safe, Affordable, Inclusive (Socially acceptable)

Diverse modes in Asia

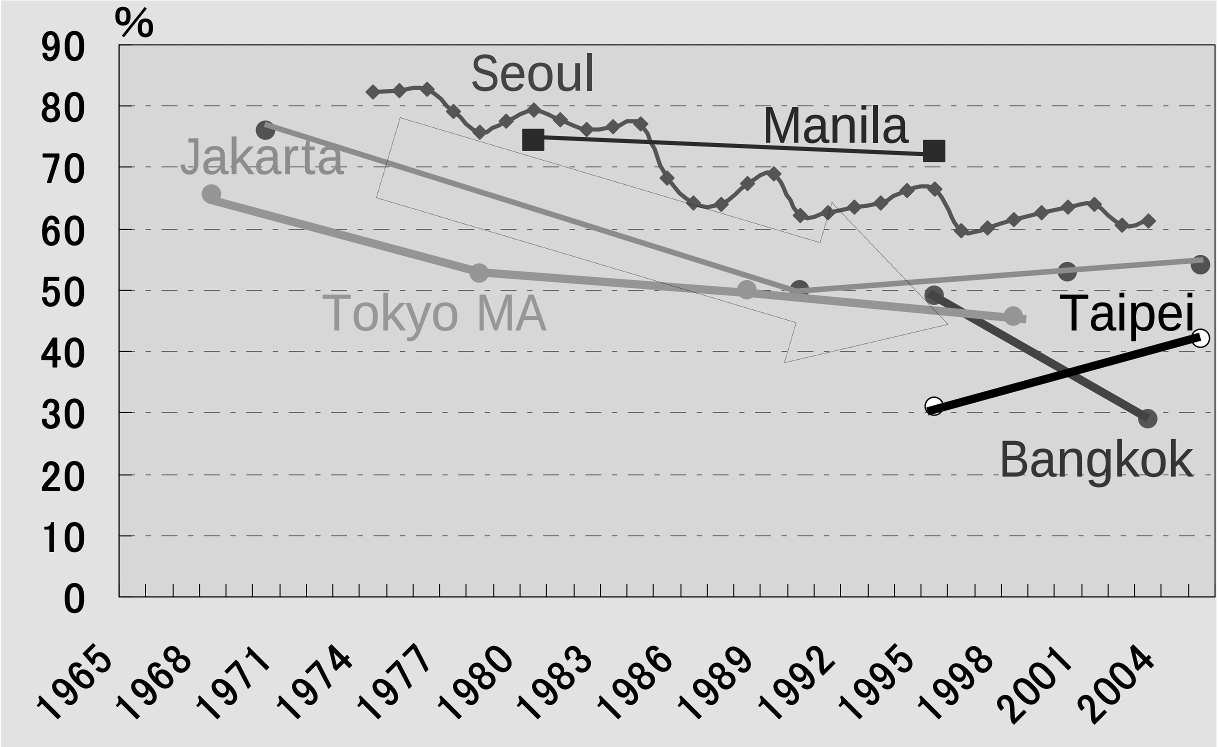
Modal split（1998～2004）



出所:　Compilation by STREAM Study (2006)

Developing cities：Bus & Para-transit main modes for Public Trans.

Trends of public transport mode share



☞In general, public Transport mode share on declining trend

Asian megacities: breeding ground for Public Transport reform

Examples:

- **Tokyo, Osaka, Seoul: Extensive MRT network**
- **Taipei, Shanghai, Beijing, Bangkok: Rapid expansion of MRT network**
- **Seoul, Taipei: Innovative bus reform**
- **Jakarta: introduction of BRT System**

<u>BRT for Asian megacities</u>

- **Low-cost alternative for MRT??**
- **Capacity and road space issue**
- **BRT Vs MRT → BRT + MRT**

Policy experience: Bus reform

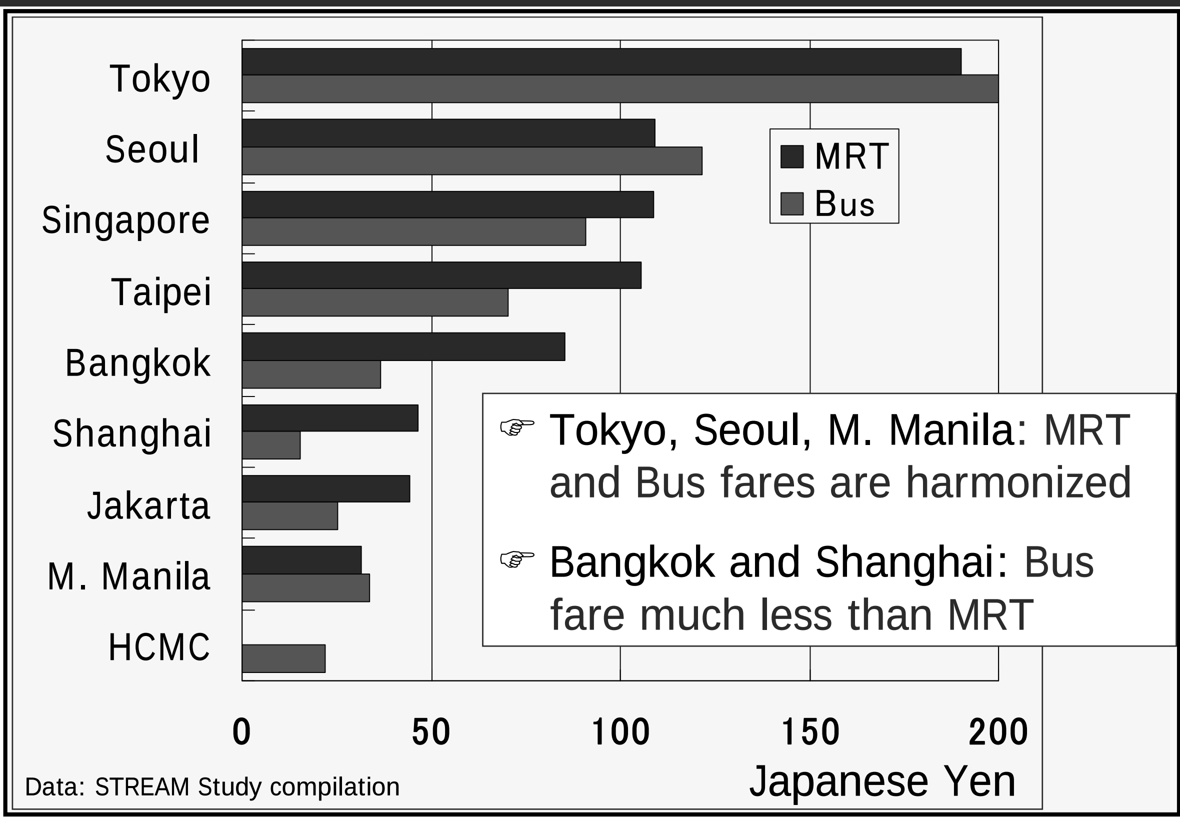
Bus reform in Seoul and Taipei:

Common features

- Comprehensive reform: modernization, Median bus-lane, IC-ticketing, fare and service integration with MRT, fare-discount for transfer (distance-based fare)
- Improvement in service and ridership, Differences:

Taipei	Seoul
Reform through gradual process	Reform through major intervention
Ownership and operation largely by private sector; regulation by public sector	Public-private partnership in management and operation, significant role of public sector
No direct subsidy (indirect cross-subsidy from MRT for fare discount)	Significant financial burden on public sector (direct subsidy)

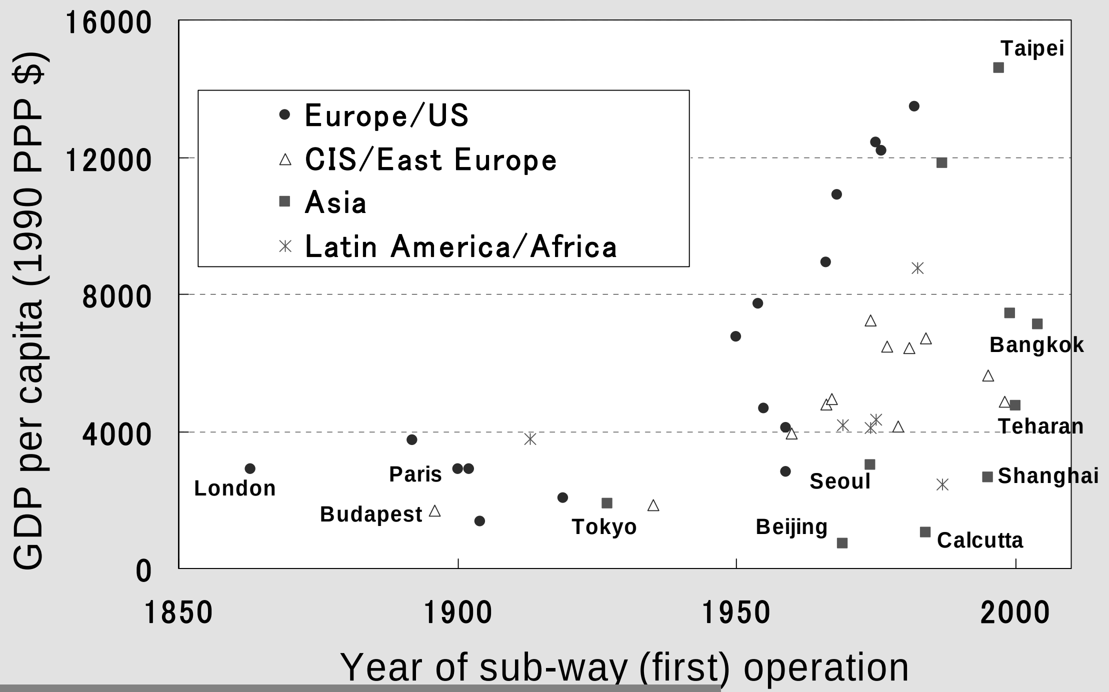
Public Transport Fare for a 10 km one-way trip (2007)



Note: Bus fare is for Air-conditioned bus; LRT in M. Manila and BRT in Jakarta are considered as MRTs.

Timing of subway opening: Income stage

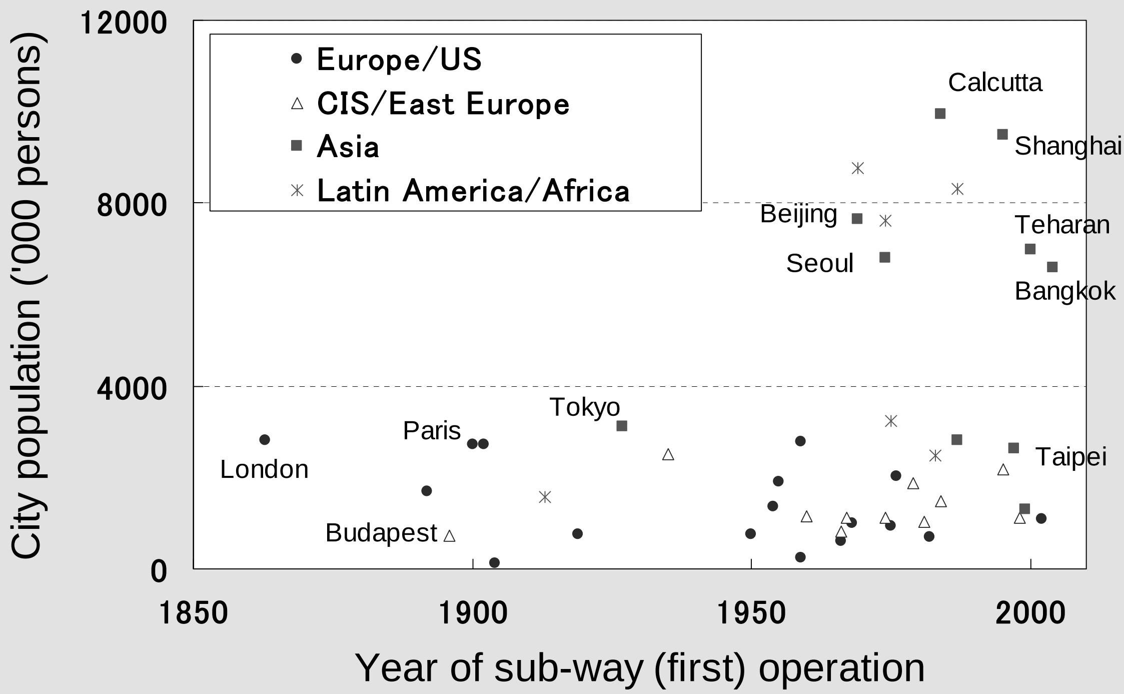
Opening year of the first subway and income per capita



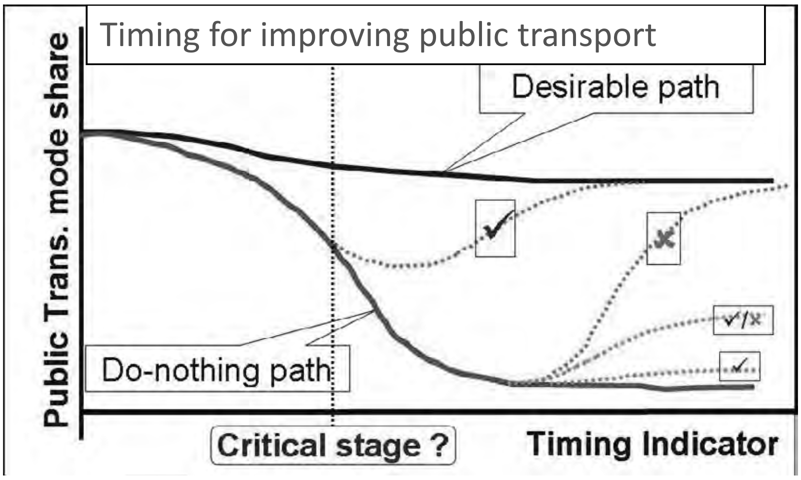
Data source: OECD (2003); http://osamuabe.ld.infoseek.co.jp

Timing of subway opening: City population

City population and opening year of the first subway



Timing of MRT development: to maintain the high share of public transport mode



Multiple timing indicators

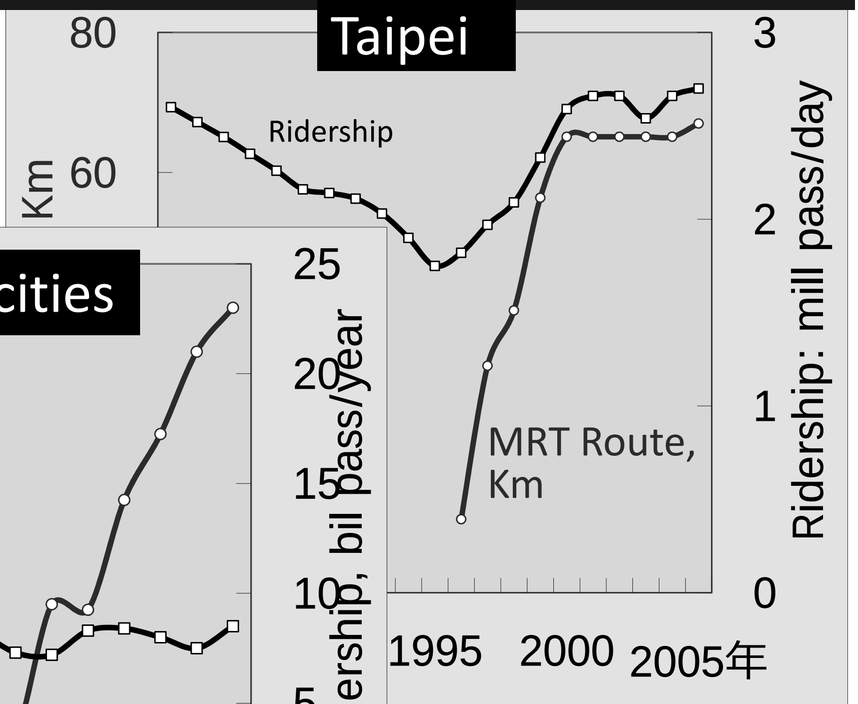
Indicators	Right timing when….
Income	**high enough** for charging reasonable fare
Car ownership	**not too high** to ensure good patronage
Population	**high enough** for threshold demand volume
Urban density	**Not too low** for required passenger density

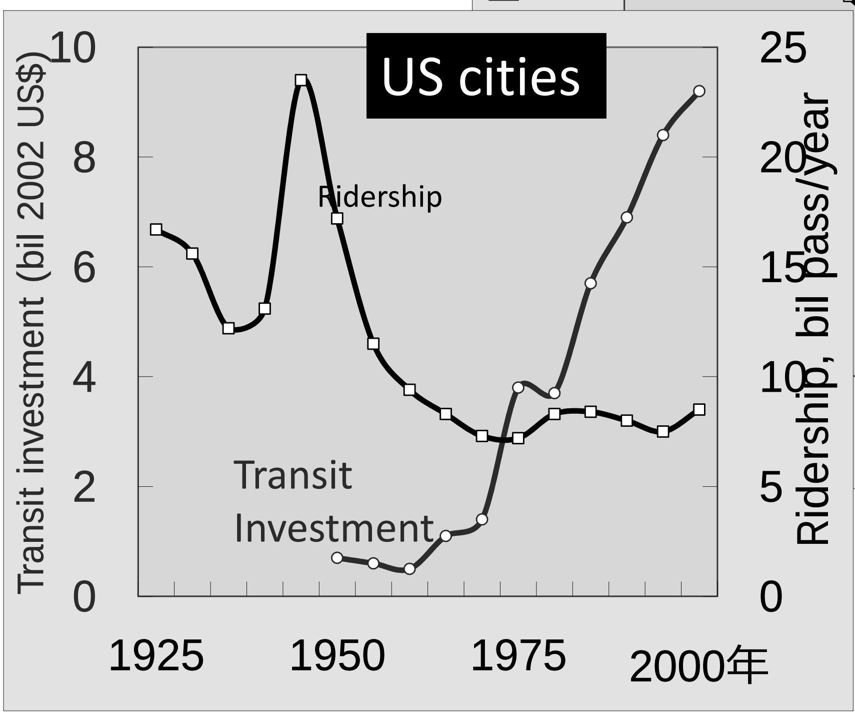
☞ Timing should be decided considering the state of all indicators !

Timing of transit investment and ridership trend

Taipei : Investment not too late

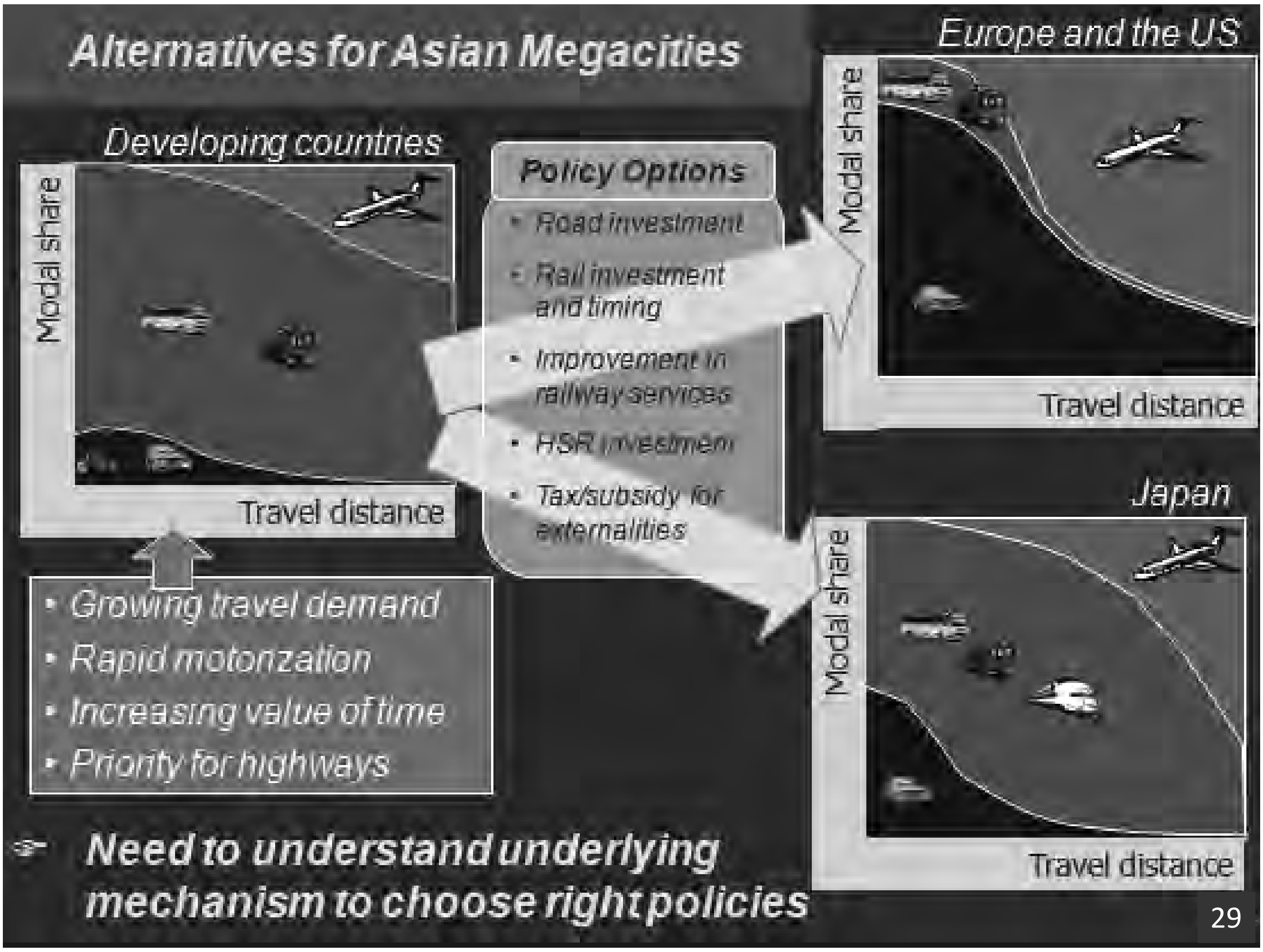
→ Ridership regained





US : Late investment

→ only marginal gain in ridership



④ Recommended issues for urban railway in Asia

Modal share is still high in Asian Megacities, however it is going down under the growing economy and motorization.
What are recommended issues ?

1. Without Railway, with BRT and with LRT,
   it is impossible to manage the transport in Asian Megacities.
2. Hierarchy railway network is required in future for megacities
   as same as road network.
3. Profitability of railway operators is required
   for the Innovation of service and technology.
4. The fare of Bus and para-transit have to be compatible to railway.
   Bangkok case is remarkable for successful higher fare.
5. The timing of investment for urban railway is important,
   however the master plan should be prepared at early stage.
   The master plan of urban railway network in Tokyo in early1960's

Published in July 2012.

Springer
the language of science

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Shigeru Morichi, National Graduate Institute for Policy Studies (GRIPS), Tokyo, Japan; Surya Raj Acharya, Institute for Transport Policy Studies (ITPS), Tokyo, Japan (Eds.)

Transport Development in Asian Megacities

A New Perspective

The rapid growth of the Asian urban population concentrates on a few large cities, turning them into giant megacities. Despite new theoretical insights into the benefits of megacities, the emerging Asia is facing a daunting challenge concerning the management of infrastructure and services in their megacities. The deteriorating urban mobility is the most difficult challenge with respect to the sharp increase in vehicle numbers and to inadequate and poorly managed road infrastructure. Public transport, a sustainable mode of mobility, is subjected to a vicious cycle of poor service, decreasing ridership and lower investment. Despite various policy initiatives, the situation has not improved. The scale and growth pattern of Asian megacities have distinctive features which generate a unique set of challenges and opportunities. New perspectives are needed to effectively address the transportation problems making the best use of available opportunities. This book, which is a result of an international collaborative

⑤ Trend of the Transport Policy in Japan

~ 1950 Development of Extensive Urban Railway Network

1950's
- Expansion of Transportation Network, Institutions for Development

1960's
- Improvement of Terminal (Rail, Bus), Law for Car Parking Space
- Horizontal Division of Rail and Road
- Direct Operation between Subway and Suburban Rail etc.

1970's
- New Transportation Systems
- Transportation System Management
- Rail – Bus Transfer Terminal, etc.

1980's
- Transportation Demand Management
- Privatization of Japan National Railway

1990's
- Public – Private – Partnership
- Incentive Scheme for Private Railway

2000's
- Coordination Scheme for Transport Industries

New Policies for Better Connectivity and Service

- 2005: The Law for Urban Railway Improvement
- : The Law of Passenger Information for Foreign Travelers
- 2006: The Law of Universal Design
  - ① Accessible and Usable Building Law
  - ② Barrier Free Transport Law
  - ③ Transfer Service Improvement
- 2007 : The Law for improvement of Regional Public Transport
- : The Law for Regional Infrastructure Improvement
- 2008: The Law for Regional Railway
- 2009: The Law for Safety of Taxi (Improvement of Deregulation Policy)
- 2009: The Basic Law for Transportation (not approved)
- 2010: The Law against Tsunami Disaster

Today's Additional Topics

1. Self-controlled organization.
   Company have to be able to decide management, investment, service and fare.
2. Performance of network is important.
   Transfer service between railway lines and between rail and road transport.
3. Priority of urban and railway development.
   Master-plan and coordination of development .
4. Advantage and constraints of PPP scheme

1. Self-controlled organization : Railway operator

Railway Company has to be able to decide the strategy
such as management, investment, service and fare.
But regulations for safety and report of information are essential.

Failure Case : JNR bankrupt through the following reasons.

* ＊ Lack of freedom of management
  * ・Control of fare by congress
  * ・Regulation of businesses except railway related one.
* ＊ Lack of incentive for the efforts to improve the efficiency
  * ・Weakness of management
  * ・Strong labor union supported by some political party
  * ・Investment for unprofitable projects by political pressure
  * ・Low service level for customers

Successful Case : Privatization of JNR・・・better service & efficiency
Many countries follow the privatization of National Railway.

Balanced policy for regulations and incentives

Major policy issues in US and EU :

Benchmark regulation to improve the efficiency of railway operators
Expansion of network through public investment
Better service and fare through government efforts

Major policy in Japan :

Incentives for railway operators
Private railway operators and operators by Local governments
make efforts for better service under the competition
Only profitable operators can innovate the railway system
R&D, Expansion of network, Improvement of System, etc

To keep the future profitability

Organization, Management, Efficient technology, Subsidy,
Suitable fare level, Consistency between rail and
urban development, etc

Profitability of Urban Railway

- Subsidy for Subway
  Japan : 50% of Subway Construction Cost
  (25% Government, 25% Local Government)
  No subsidy for operation cost
  US & EU : 100% of Construction Cost
  20-80% of Operation Cost
- Profitability
  Except Japan, Only Taipei : profitable for operation cost
  Railway operators in Tokyo enjoy the profitability
  (At the first stage not profitable)
- Only the profitable railway companies
  innovate the system, technology and service.
  Unprofitable company cannot take the risk to change the system.
- All railway operators in Tokyo enjoy the profitability.

Operational characteristics of selected subway systems

(2005)

	Tokyo		Seoul[1]		Taipei	London	New York[2]
	Tokyo Metro	Toei	Seoul Metro	SMRT			
Route (km)	183	109	135	152	67	408	371
Passengers (mil/year)	2,110	761	1,440	819	361	971	1449
Pass/km/day (1000 persons)	**32**	**19**	**29**	**15**	**15**	**7**	**11**
Revenue /cost	**1.29**	**1.07**	**0.74**	**0.55**	**1.07**	**0.59**	**0.51**
Fare (US$)	**1.3 ~ 2.5**	**1.4 ~ 3.5**	**0.8 ~ 1.1**		**0.6 ~ 1.9**	**3.0 ~ 8.0**	**2.0 ~**

1. data year 2003, 2. revenue/cost includes also of bus
2. Data source: Seoul (Sung 2007), rest from homepage of respective agencies

☞ Only Tokyo and Taipei operators are profitable.

Financial Resources for Public Transport

① Fare	・・・・・・・・・・・・・	Regulation or Deregulation
② Cross Subsidy ③ Value Capture	]・・・・・・[	Operators' Initiative Regulators' Role
④ Subsidy	・・・・・・・・・・	Public Sector's Decision

① Fare for Profitability

- Balance between Bus and Railway
  Competition under the Different Costs
- Regional Disparity between Prior and Inferior Regions
- Transport Behavior by Income Segmentations
  and the Time Series Change

Philippines' Example :
LRT3 Fare and Deregulation for Air-conditioning Bus
Thailand' s Example:
High Fare for New Urban Railway : High Income Passengers

② Cross Subsidy between Routes

- Profitable and Efficient Organization
- Profitability of Urban Railway Operator
  Tokyo Metro and Hanoi Metro
- Rationale for Cross-subsidy
- Independent PFI Projects

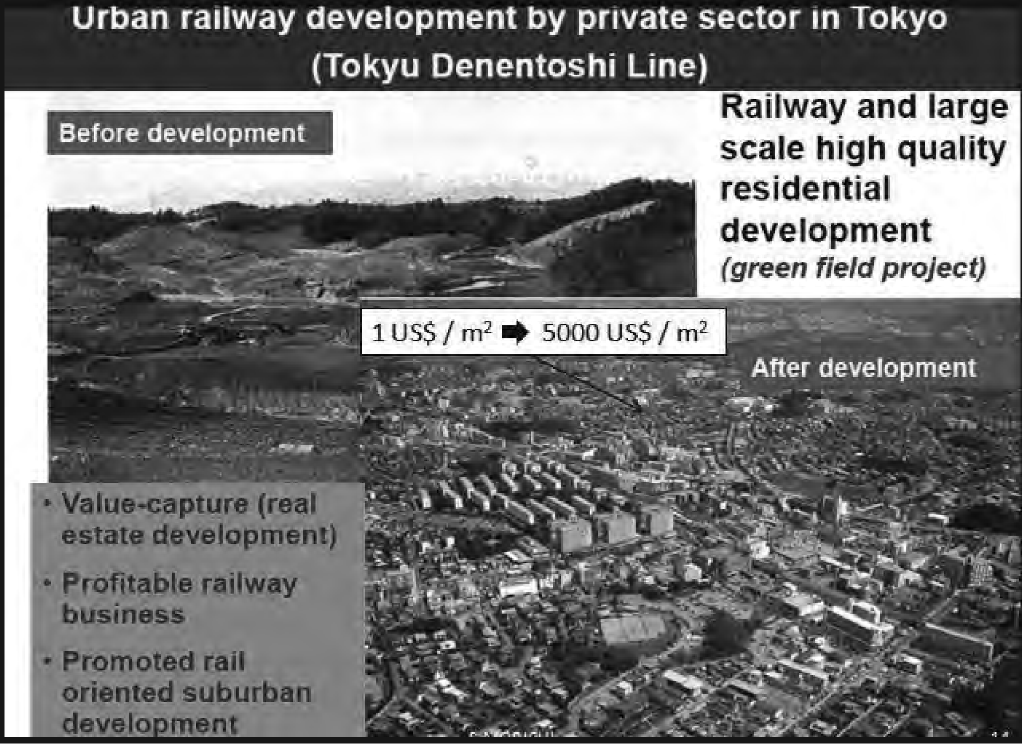
③ Subsidy

- Disincentive for efficiency
- Incentive for Operators
- Neutral for Transport Modes
- Difference between EU, US and Japan
- Role of Government for PFI Projects

④ Value Capture

④ Value Capture

- Transit Oriented Development
- Multi-core Urban Structure for Mega Cities



From Japanese experience:

- Urban railway can be profitable.
- Main Revenue of railway company

  1st step (Population is limited) : housing, real estate

  2nd step (population increased) : high land price,

  all business increased railway passengers

  3rd step (almost land was sold out) :

  railway, urban renewal, etc
- Profitability is essential for innovation of system.
- Railway Company is key factor of attractiveness of area

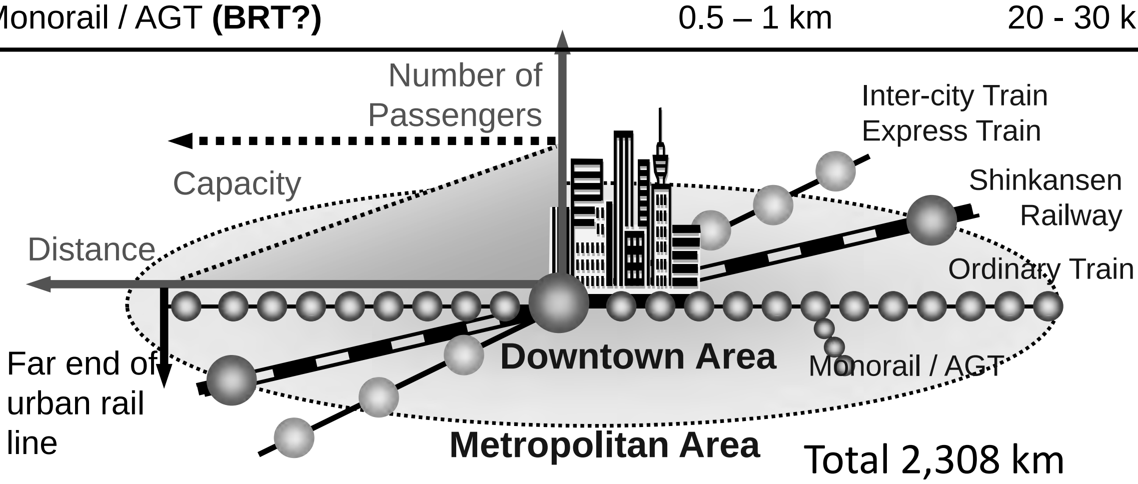
  (Attractiveness decides the land price)

2. Performance of not only lines but also network

* Direct operation between different lines, different operators
  - Subway and suburban railway : Tokyo case
  - Intercity trains start from subway station (Odakyu & Tokyo Metro)
* Transfer service between railway and other modes
  - Station plaza : for Bus, Taxi, and Cars.
  - Universal design of the routes for pedestrians inside station and from station to surrounding facilities
  - Connection of urban railway to inter-city transport terminals such as HSR station, airport and bus terminal.
* Hierarchical urban railway network in mega-city
* IC Cards Based Common Ticketing System
* Information system and reservation system

Hierarchy of Urban Railway Network (Tokyo)

Railway Type	St. Spacing	**Operating Speed ***
Shinkansen Railway (Bullet Train)	30 – 50 km	120 -130 km / hr
Inter-city Train (Japan Railways) Express Train (Private Railways)	5 – 6 km	50 - 60 km / hr
Ordinary Train (Private Railways)	1 – 2 km	40 - 45 km / hr
Subway	0.5 – 1 km	30 - 35 km / hr
Monorail / AGT **(BRT?)**	0.5 – 1 km	20 - 30 km / hr



Total 2,308 km

IC Cards Based Common Ticketing System

JR

Private Rail, Subway, Bus

JR East
Tokyo Monorail
Tokyo Rinkai

Passnet
(magnetic card)

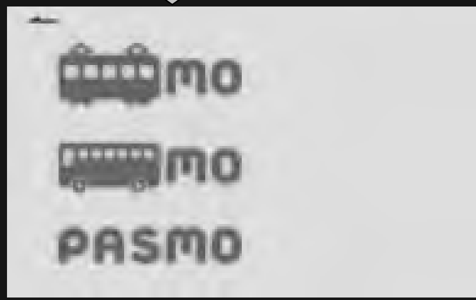
+

Bus Card (30 Co)
(magnetic card)

Railway Co : 26

Standardization
2007

Common
Ticketing
2007



Collaboration with other regions and fields

2009: Common ticketing with JR Hokkaido
2010: Common ticketing with JR Kyusyu and urban railway in Fukuoka
2011〜 : Common use with many shops and restaurants
2013: Common ticketing and use all over the Japan

Collaboration with other regions and fields

2007: Common use between JR and Private Railways
2009: Common ticketing with JR Hokkaido
2010: Common ticketing with JR Kyusyu and urban railway in Fukuoka
2011〜 : Common use with many shops and restaurants
2013: Common ticketing and use all over the Japan

Requested higher performance of IC card Ticketing System

- Capacity of ticket gate
- Failure rate of passage
- Possibility for future performance
- Possibility common use in wider region
- Higher reliability for usage in many fields

Master plan for urban railway in metropolitan areas

Major factors discussed in the planning

＊Demand: Trip generation, Distribution, Modal Split, Route assignment
（Economical growth, Population, Car ownership, Urban Development)
＊Social Needs
: Transportation problems: Congestion, Service level, Environment, Universal design, etc.
: Cost and Benefit Analysis
＊Coordination between railway network and related plans :
Plans of other transport modes, Regional & Urban Plan, Environmental plan, etc.
＊Feasibility of each line : Profitability, Financial viability, Agreement of stakeholders
＊Long term strategy is very much important : Early stage planning

Tokyo Case

＊ 12 lines in existing 13 lines have been approved in MP in 1960's
＊ Urban Railway Policy Council proposed the master plan in every 10-15years
＊ Government issues the license of the construction in this term only for proposed lines
(If necessary, the Master Plan will be revised)
(Local governments and railway operators have to prepare carefully)
＊ The Council Members : Professors, central government, municipalities, railway operators, mass communications, etc.
＊ Proposed lines in last Master Plan
A1 Lines :which should be operate in the term(e.g. 15 years)
A2 Lines which should be start the construction in the term
B Lines which should be evaluate in the term

3. Priority of urban and railway development

Railway project is different from road project

- Large demand risk, High initial cost, Limited subsidy
- Planed length of route have to be opened in targeting term
  (Delay of project means its bankrupt)
- Planed land-use along the route is important for the profitability
  (Lack of demand in initial term means its bankrupt)
- Urban development requires the simultaneous investments of various infrastructures and agreement of many organizations

⇓

＊Coordination between Master-plans of Urban Plan, Transportation Plan and Railway plan.
＊Coordination of related development projects

Coordination between transport and urban planning

1) Legal level coordination

ex. ・Urban Planning law
  Urban planning procedure for transport facility
 ・ Environment assessment law
 ・Special law for the railway between Tokyo and Tsukuba
  (Housing area and railway development law)

2) Institution level : Budget and system for coordination

ex.・Subsidy for new town railway
 ・Subsidy for continuous vertical division of railroad crossing

3) Planning level coordination

ex. ・Coordination by Local Government
 ・Planning Committee :
  Professors, related agencies and stakeholders

Vertical Separation of Railway Systems

Concept: Ownership of infrastructure and operation of services by different entities

Repayment type

Continual

Public development system

Railway operator and passenger bear the costs for all or a part of construction

Public sector develop infrastructure and lease to railway operator under the agreed terms

Multimodal Policy

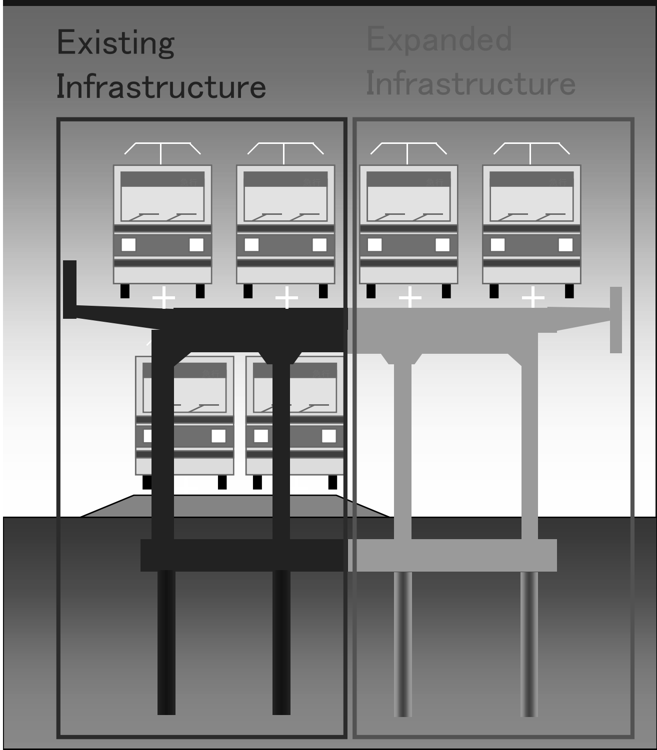
Rail to Rail
- -Improvement of Transfer Facilities in Terminals
- -Direct Operation between Subway and Sub-urban Railway

Rail to Road
- -Grade Separation between Rail and Road Crossings
- -Station Plaza
- -Rail – Bus Transfer Terminal

Station to Surrounding Area
- -Under Ground Shopping Area
- -Skyway
- -Commercial Station Building

Software Improvement
- -Information System
- -Fare Discount for Transferring
- -IC Based Common Ticket

Subsidy for Grade Separation of Rail and Road Crossings



- Ensuring smooth traffic flow and promoting local interaction
- Distributing financial burden between road and rail sides

		Financial Burden	
Construction Cost	Elevation of Existing Infrastructure	Road	86–95%
		Rail	14– 5%
	Elevation of Expanded Infrastructure	Road	0%
		Rail	100%

e.g. Network Expansion and Better Accessibility

① Tokyo: New Subway line (Fukutoshin Line)

- Connect major sub-centers
- Direct operation : 3 lines
- Design of stations
- Local and express trains in subway

Opened in June 2008

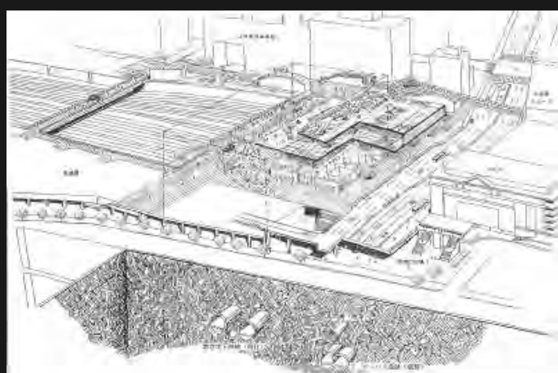
② **Osaka:** Nakanoshima-line (along the river)

Opened in Oct. 2008

Stations along riverside

- ☞ Attracted new investment for development around river-side stations
- ☞ Contributed to urban renewal in the city core areas

Terminal Renovation : Shinjuku Station



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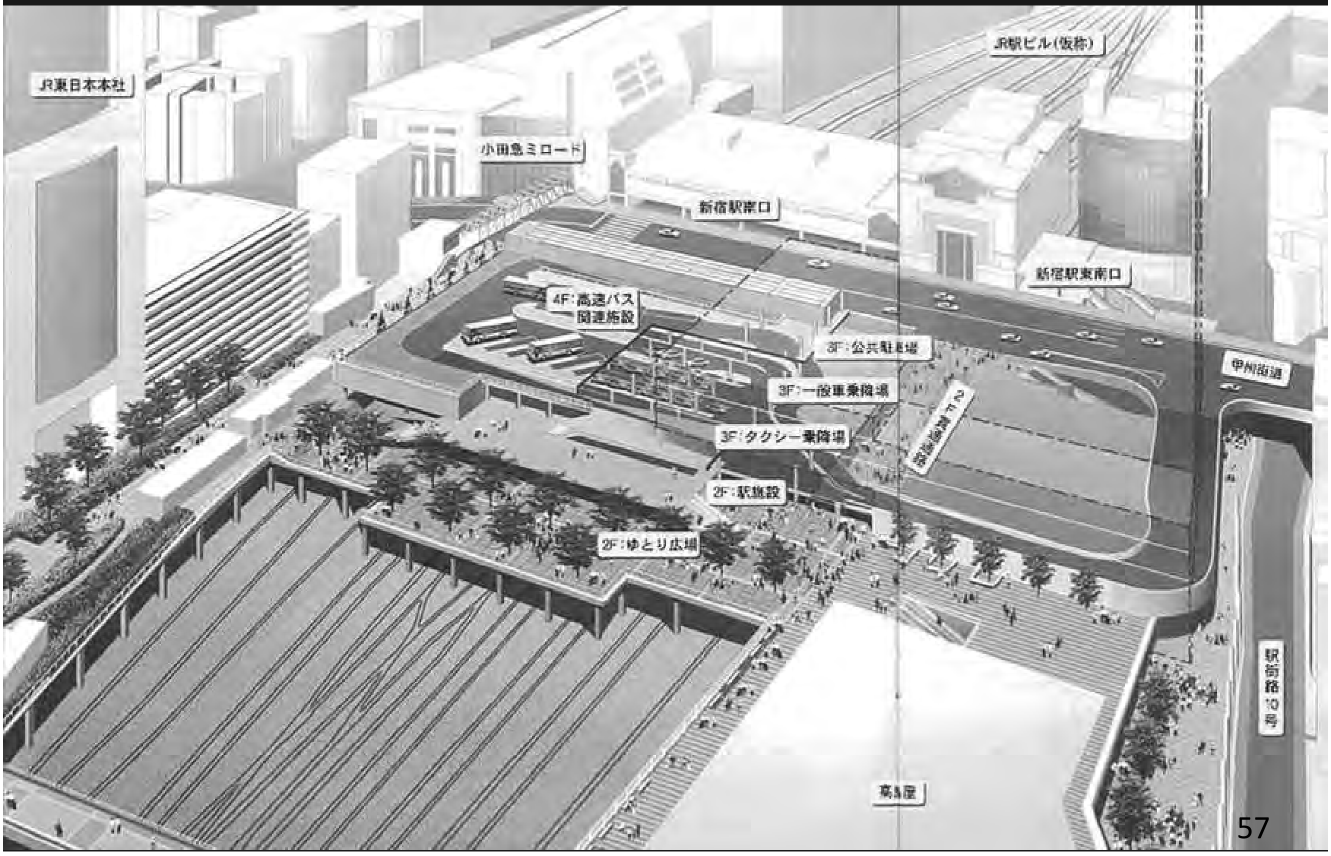
Space Utilization above Railway Tracks



4. Advantage and constraints of PPP scheme

- Limited successful projects
- Failure of public and private sectors
- Competitiveness of the country and the project in the world-wide market

  Country risk and project risk
- Difference the optimizations between public and private sector
- Lack of cross subsidy
- PFI project for urban railway with public subsidy

Ⅵ. Conclusion

1. Transit oriented system

   Car oriented system brings :

   Low density land-use and sprawl in suburban area

   Difficulty of railway development forever

2. Timing of Urban Railway Development

   To avoid the difficulty of recovery

3. Transport mode selection

   For future demand・・・Low capacity modes for only feeder route

   To keep the possibility of capacity expansion

   MRT ; Elevated or Subway

   LRT ; Surface or Elevated

   Monorail / AGT ; mainly elevated

   Not for trunk route

   Only for limited area

   BRT ; only for feeder route in mega-city

4. Master Plan in early stage

   Future hierarchical railway system is requested

   Coordination between urban development and railway

5. Profitability of urban railway

   Efficiency and high quality of transport system

   However subsidy and related policies are essential.

   High construction cost and low fare level means lack of feasibility.

   Especially at first stage, financial support is necessary.

Thank you for your kind attention !

Securing the Safety of Railway Transportation
—System and Practical Business in Japan —

November 2013

Atsushi Kawai, Advisor

1. Organizations related to Railway Safety

○ Railway operators

- Provide transportation services to the nation's citizens under license of the national government.
- In addition to privately-financed companies, also include rail systems operated by local governments and companies financed by the national government/local governments.
- Some operators (Type III Railway Business Operator) own infrastructure and lease those facilities to an operating company.

○ Competent authorities (Railway Bureau, Ministry of Land, Infrastructure, Transport and Tourism (MLIT))

- Performs policy-making for railway operation as a whole.
- Grants business licenses to railway companies, and provides guidance and support for safe operation and sound management.
- Provides the necessary funding and information to the following organizations.

○ Japan Transport Safety Board (established in MLIT)

- Investigates the causes of railway accidents and incidents, and makes proposals and recommendations for prevention of recurrence.
- Provides appropriate information to the victims of accidents and their surviving families.

○ Japan Railway Construction, Transport and Technology Agency (Independent Administrative Agency; an agency of the national government)

- Performs construction of railways at the request of the national government and railway operators and loan of the constructed railway facilities.
- Implements government assistance for railway operators.

○ Railway Technical Research Institute (Public Interest Incorporated Foundation; a foundation operated with funding by the JR Group, etc.)

- Performs technical development and research related to railways.
- Provides results to railway operators, and performs technical assessments and technical support.

- Proposes technical standards to the Railway Bureau, and provides technical support for the Transport Safety Board.

○ Manufacturers, construction companies, etc. (private-sector companies)

- Provide safe, high quality products and services to railway operators, etc.

2. History of Business System related to Railways

・1869: Decision to construct railways by the government

1872: Start of operation of railway between Tokyo and Yokohama (30km; nationally-owned)

*Until the 1890s, technology was introduced from England.

1883: Start of operation of first private railway

*Subsequently, a large number of main lines were constructed with private capital.

・1906: Nationalization of main rail lines

*Following this nationalization, private capital was responsible for construction of local and regional railways in urban areas, etc.

*The main rail line network was substantially complete in the 1920s.

1927: Start of operation of first subway (2.1km)

1941: Establishment of the Teito Rapid Transit Authority (now Tokyo Metro Co., Ltd., funded by the national government and city of Tokyo)

・1949: National railways were transferred to a public corporation (Japanese National Railways; JNR)——Separation of business and governmental control

1964: Start of operation of Tokaido Shinkansen (515km)

・1987: Privatization of JNR and separation into 7 companies——Establishment of the present business system

2001: Establishment of the Aircraft and Railways Accidents Investigation Commission (now Transport Safety Board)——Creation of an independent accident investigation organization

2004: Establishment of Tokyo Metro Co., Ltd. (privatization)

*Rail networks in metropolitan areas are substantially complete.

3. Present Legal System for Railways

○ Railway Operation Act

- Law prescribing the basic rights/obligations of railway operators, users, etc.

- An old law enacted in 1900; special measures act of the civil code and penal code.
- Forms the basis law for technical standards and other basic regulations (ministerial ordinances) which should be observed by railway operators.

○ Railway Business Act

- Law regulating the railway business in a unified manner.
- Defines the authority of competent authorities in licensing of newly-constructed routes, approval of fares and freight charges, completion inspections, on-site inspections, etc. and the obligations, procedures, etc. which should be performed by railway operators.

○ Tramway Act

- Law regulating railways laid on roads (tramways, new transportation systems, etc.)
- In addition to the content of the Railway Business Act, also provides matters related to management of roads.

* These laws regulate all operators nationwide in a uniform manner; the actual situation of each company and each route is decided on the responsibility of the operator.

4. Securing the Safety of Railway Transportation (1) Duties of the Railway Bureau

○ Establishment of ministerial ordinances

- Criteria for securing safety
- Technical standards ― Necessary technical matters are provided by performance requirements (Performance-based Regulation)

* Operational details are covered by non-binding notifications (Model Code, etc.)

- Inspection methods for facilities and rolling stock
- Accident reports
- Other matters prescribed by law

○ Publication of safety information

○ Practical business based on laws and ordinances

- Licenses for construction and facility modifications
- Completion inspections of facilities, checks of rolling stock

- Qualification tests for train drivers — In case of large operators, practical business is entrusted to each company, and the contents of education, testing, etc. are checked.
- On-site inspections (safety audits, audits of driver training facilities, etc.)
- Instructions for business improvement (recommendations, business improvement orders, etc.)

  Etc.

○ Work related to policy implementation
- Study of measures to prevent recurrence of accidents
- Technical development for safety improvement
- Support for investment in safety by railway operators

* The Railway Bureau also prepares award systems such as commendations for accident-free operation, etc.

5. Securing the Safety of Railway Transportation (2) Responsibilities of Railway Operators

○ Establishment and maintenance of internal regulations based on ministerial ordinances

○ Establishment of safety management system
- Establishment of Safety Management Regulations
- Appointment of responsible persons, beginning with Chief Safety Management Officer
- Sharing of safety-related information from front-line work site to top management
- Establishment of check function in order to execute work in a reasonable manner

  Etc.

○ Publication of accident reports and safety information

○ Observance of matters specified in laws and ordinances and internal regulations

⇒ Secure everyday safety by implementing periodic inspections and maintenance of facilities and rolling stock and education/testing to improve the qualifications of personnel

○ Implementation of education and training assuming conditions during accidents and disasters

⇒ Establishment of a system that enables calm response under abnormal conditions

6. Key Points for Securing Safety in Railway Operators

○ Fundamentals of accident prevention

☆ In many cases, serious accidents occur as a result of multiple mistakes by personnel when minor trouble occurs.

⇒ Do not ignore minor trouble; take proper action.

—— Thoroughgoing implementation of routine inspections and maintenance.

⇒ Create an environment where personnel can respond calmly during abnormalities.

—— Correct education and training, release from stress.

☆ It is important to establish rules that can be executed under both normal and abnormal conditions.

○ Fate of organizations that hinder safety

- Management: Cost reduction, improved service, increased income and profit …

  ——Unable to listen to what the site is saying item by item ⇒ Ignore site
- Personnel at site: Severe work environment, irregular sleeping time, fear of accidents …

  ——Damage if person reports trouble to superior and is reprimanded

  ⇒ Hide trouble

☆ Important to create an environment where it is easy to report trouble, and cultivate management people who can correctly grasp/analyze the condition at the site.

7. Key Points of Safety Audits

○ Purpose of audits

The purpose of audits is not to expose violations, but to secure safety and prevent recurrence of accidents.

○ General procedure (normally, approximately 3-5 days)

- Listen to the general condition of business, measures for securing safety, etc. from management
- Document investigation of facilities, rolling stock, operation, etc. by field: Condition of maintenance of regulations, existence/condition of use of records of inspection/maintenance, etc., condition of sharing of accident information,

etc.

- Site investigation
  - (Work under normal conditions) Condition of observance of regulations, condition of management of facilities, rolling stock, etc., condition of work of personnel (degree of overtime work, taking holidays, etc.), condition of education and training, etc.
  - (Response during abnormalities) Contact system, passenger evacuation guidance methods, condition of emergency equipment such as fire extinguishers, guide lights, emergency exits, evacuation ladders, etc., condition of training in response during abnormalities, etc.
- Evaluation of condition of efforts to secure safety, analysis of problems

○ Response after audit

- If no problems, praise.
- In case small, seemingly-frequent problems are discovered, give gentle guidance.
- If serious problems such as violations of law, etc. are discovered, give strict guidance in writing, for example, "Recommendations," "Work improvement order," etc.

8. Summary

○ Since a railway system is materialized from many elements, such as rolling stock, signals, and tracks, the safety of the total system cannot be secured simply by performing proper inspection/maintenance of the individual equipment.

○ It is important to conduct training of personnel assuming a variety of cases, prepare equipment for response during abnormalities, etc. so that a proper response is possible, particularly during abnormalities.

○ The first point is how to enhance the safety consciousness and skills of the site personnel who operate, inspect, and maintain the individual pieces of hardware.

○ The second, and even more important point is the existence of a management team that takes an overview of the system as a whole and works to improve safety at all times.

Tokyo Metro's Experience

Best practices and Learning from mistakes

December 13, 2013
Tokyo Metro Co., Ltd.

Keeping Tokyo on the Move

At Tokyo Metro Group, with the railway business at the core of our business development, we support the capital city Tokyo's urban functions and make Tokyo even more attractive and vibrant. Through outstanding technology and creativity we provide safe and comfortable transportation daily, contributing to the active lives of all people who gather in Tokyo.

Capital	58.1 billion JPY (618 million USD)
Stockholders	Government (53.4%), Tokyo Metropolitan Government (46.6%)
Business contents	1. Operation and management of subway business in and around the heart of Tokyo 2. Managing other affiliated businesses (Real estate leasing business, commercial tenant business, advertising business and others)
Net sales	Unconsolidated 343.6 billion JPY (3.7 billion USD) Consolidated 382.2 billion JPY (4.1 billion USD)
Income from fares	298.6 billion JPY (3.2 billion USD)
Number of employees	8,692 employees (As of 31 March 2013)
Group companies	Commissioned railway services Real estate business Commercial tenant business with a total of 11 companies

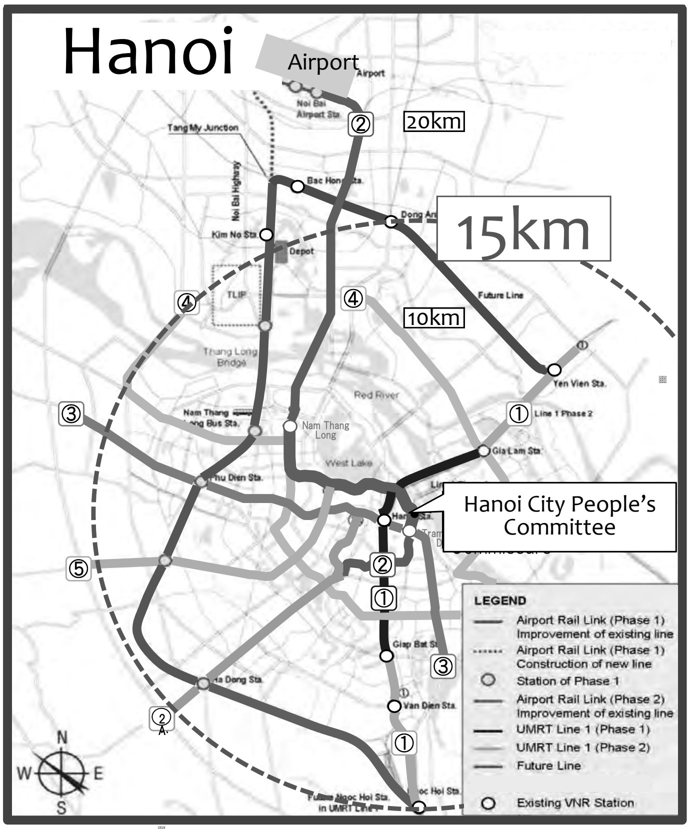
* 1USD=94JPY

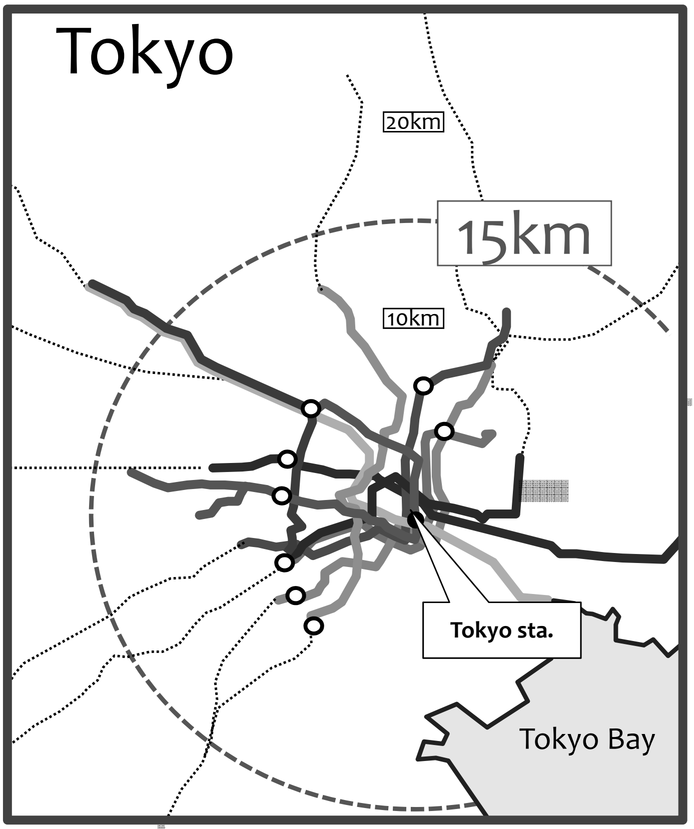
(FY2012)

Operating lines	9 Lines	Ginza	14.3 km
		Marunouchi	27.4 km
		Hibiya	20.3 km
		Tozai	30.8 km
		Chiyoda	24.0 km
		Yurakucho	28.3 km
		Hanzomon	16.8 km
		Namboku	21.3 km
		Fukutoshin	11.9 km
Route length	Total 195.1 km		
No. of stations	179 stations		
No. of cars	2,719 cars (As of March 31, 2013)		
No. of passengers	Average number per day 6.44million (FY2012)		
Minimum headway	1 min 50 sec (Marunouchi Line)		

* Toei Subway operates four other subway lines.

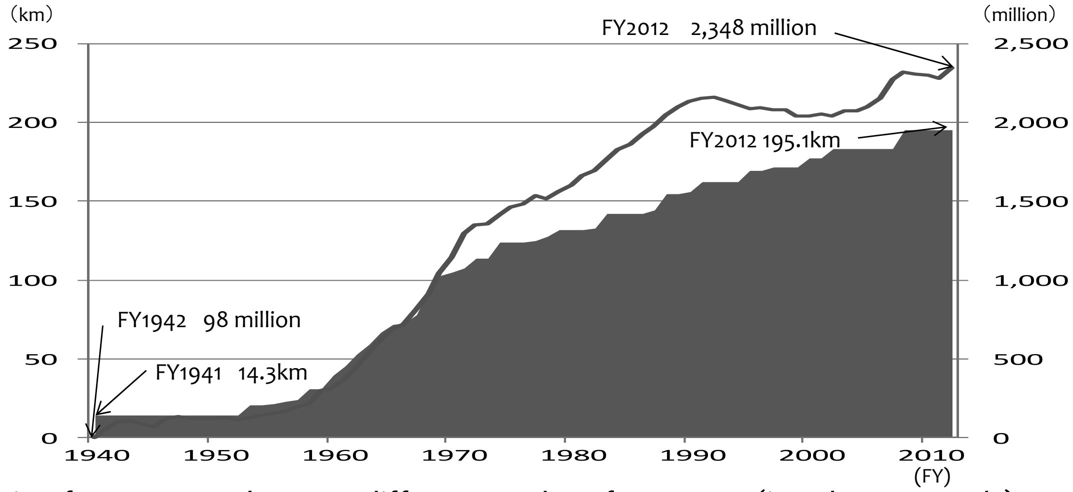
- Railway business (Comparison with Hanoi's plan)



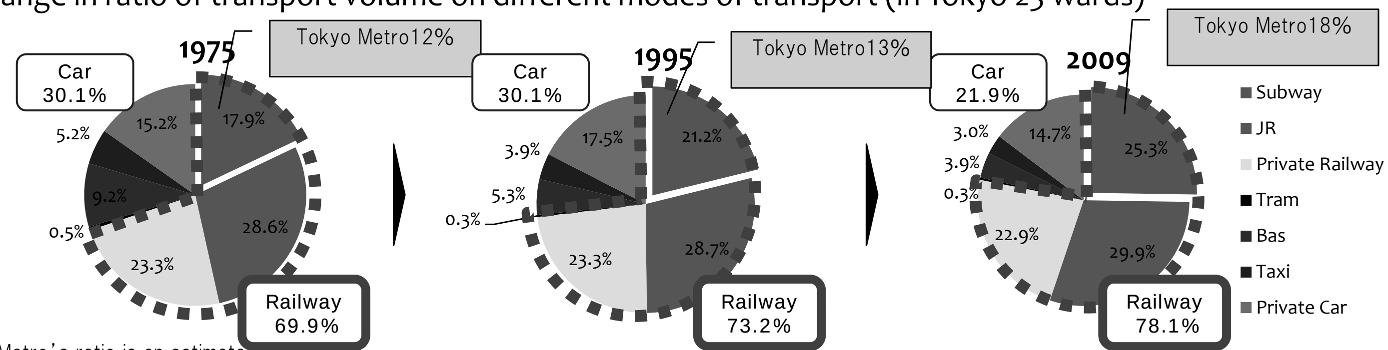


- Railway business (Change in number of passengers carried, ratio of transport modes)

(1) Change in number route length and number of passengers carried

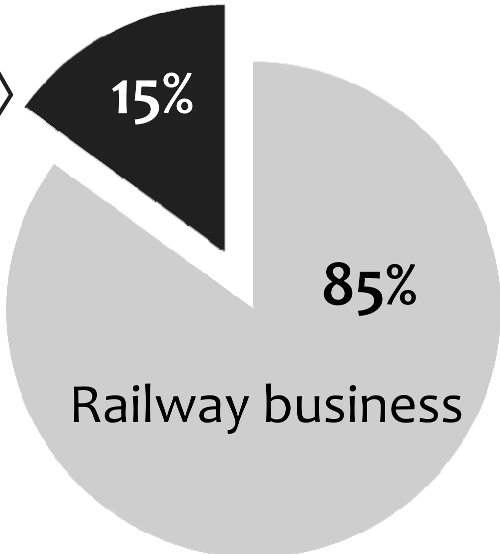


(2) Change in ratio of transport volume on different modes of transport (in Tokyo 23 wards)



＊Tokyo Metro's ratio is an estimate

1. Tokyo Metro Outline
- Related business (Ratio of total operating revenue from related business)



Total revenue of Tokyo Metro Group
4.1 billion USD

* 1USD=94JPY

1. Tokyo Metro Outline
- Outline of related business (Retail business)

• Commercial buildings

• Echika Malls

• Metropia Shops

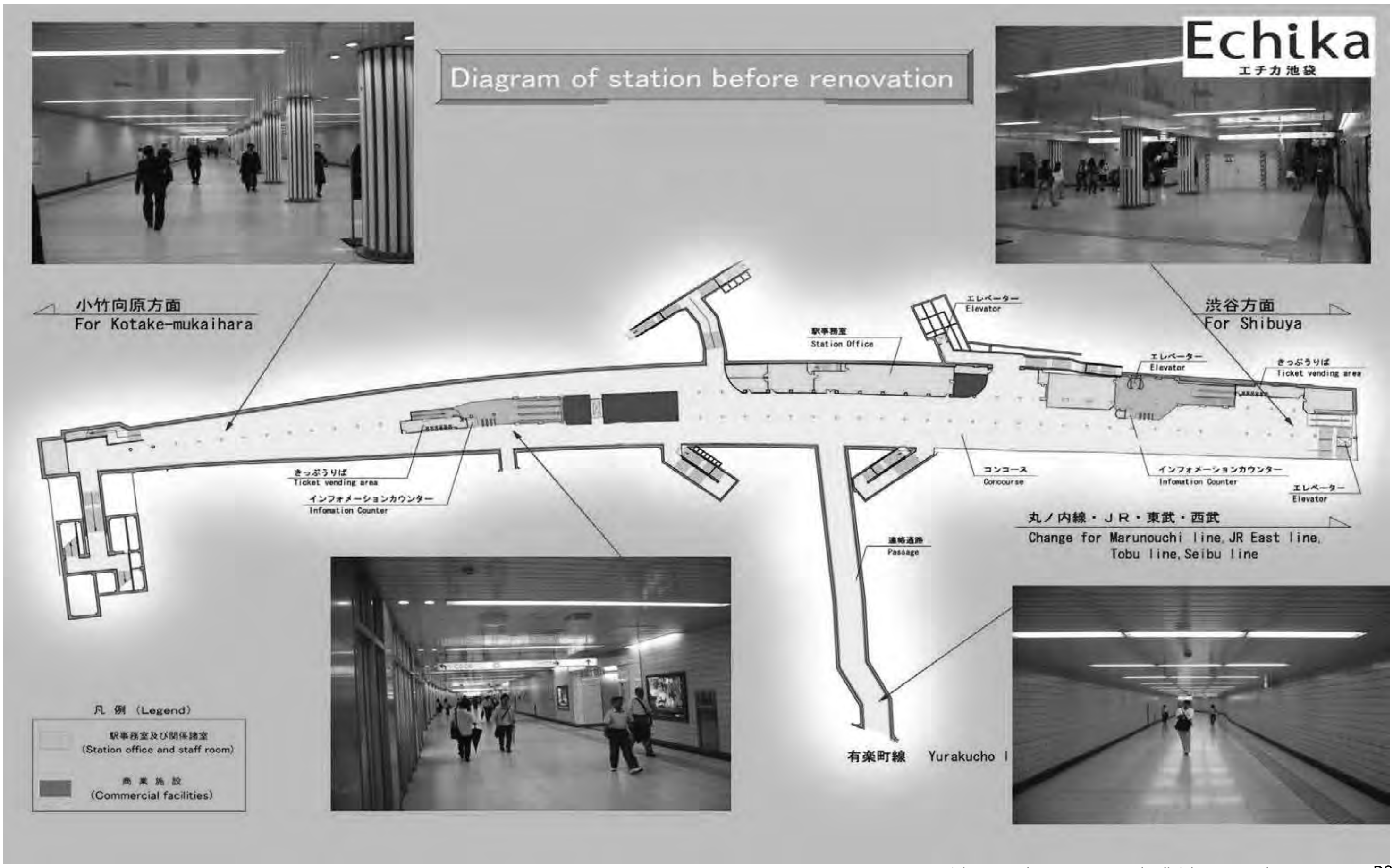
• Kiosks

• ATMs/baggage lockers

1. Tokyo Metro Outline

- Outline of related business (Echika Ikebukuro- before development)

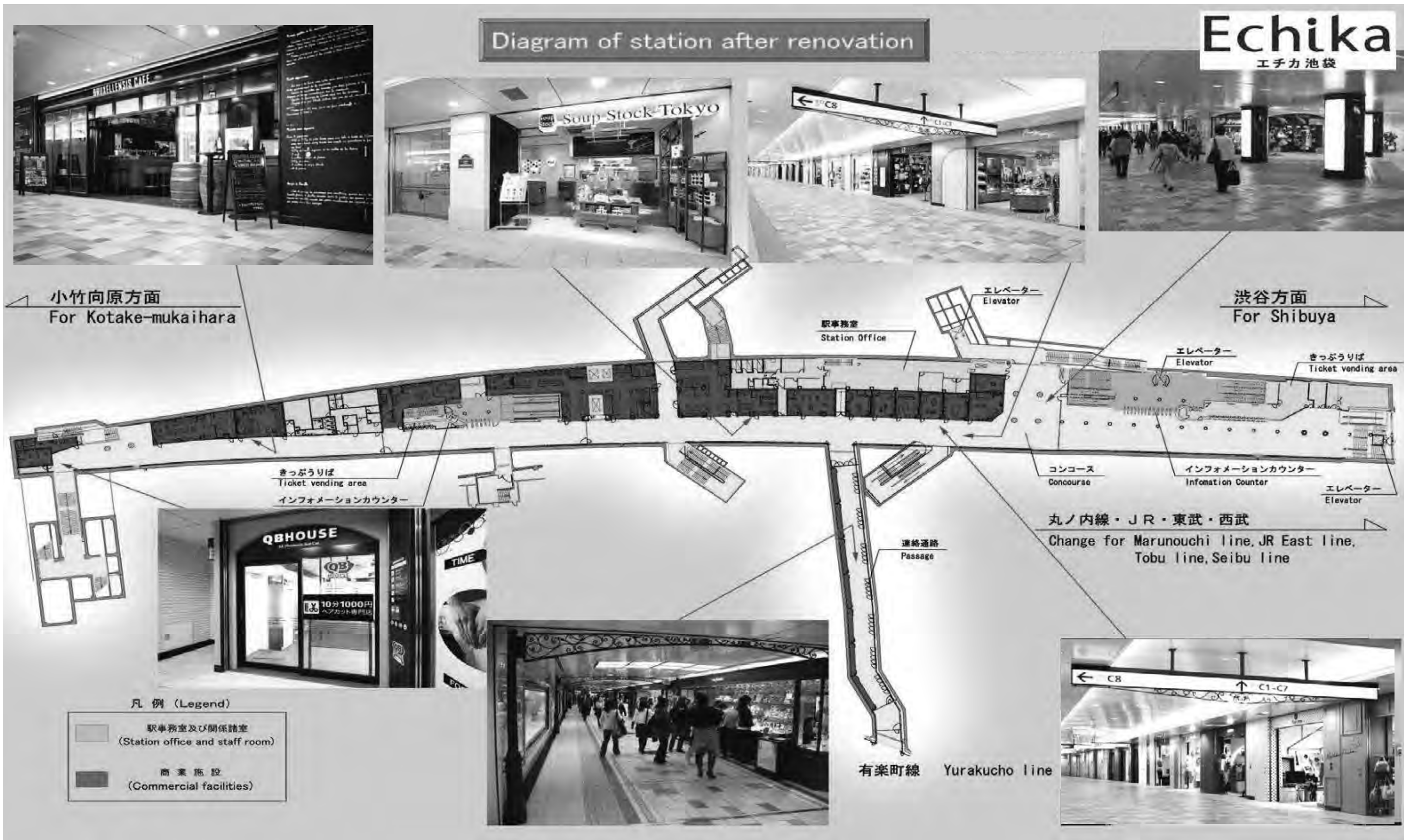
Tokyo Metro



1. Tokyo Metro Outline

- Outline of related business (Echika Ikebukuro- after development)

Tokyo Metro



1. Tokyo Metro Outline

- Outline of related business (Real estate)

• Office building

• Hotel

• Driving Range

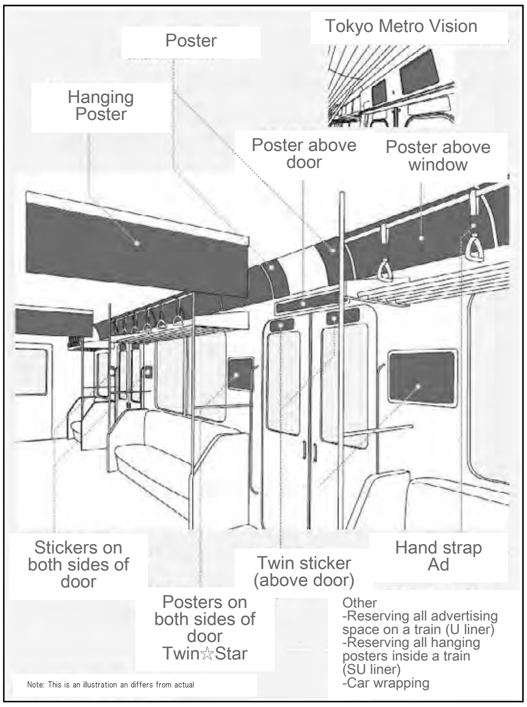
• Storage Room

• Multi-purpose Complex

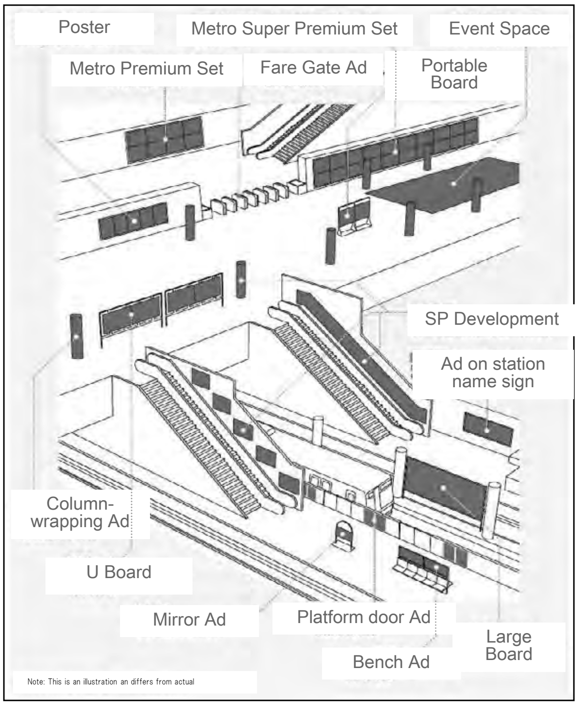
2. Tokyo Metro Outline

- Outline of related business (Advertising business)

■Advertising media on trains



■Advertising media in stations



■Digital signage

On trains

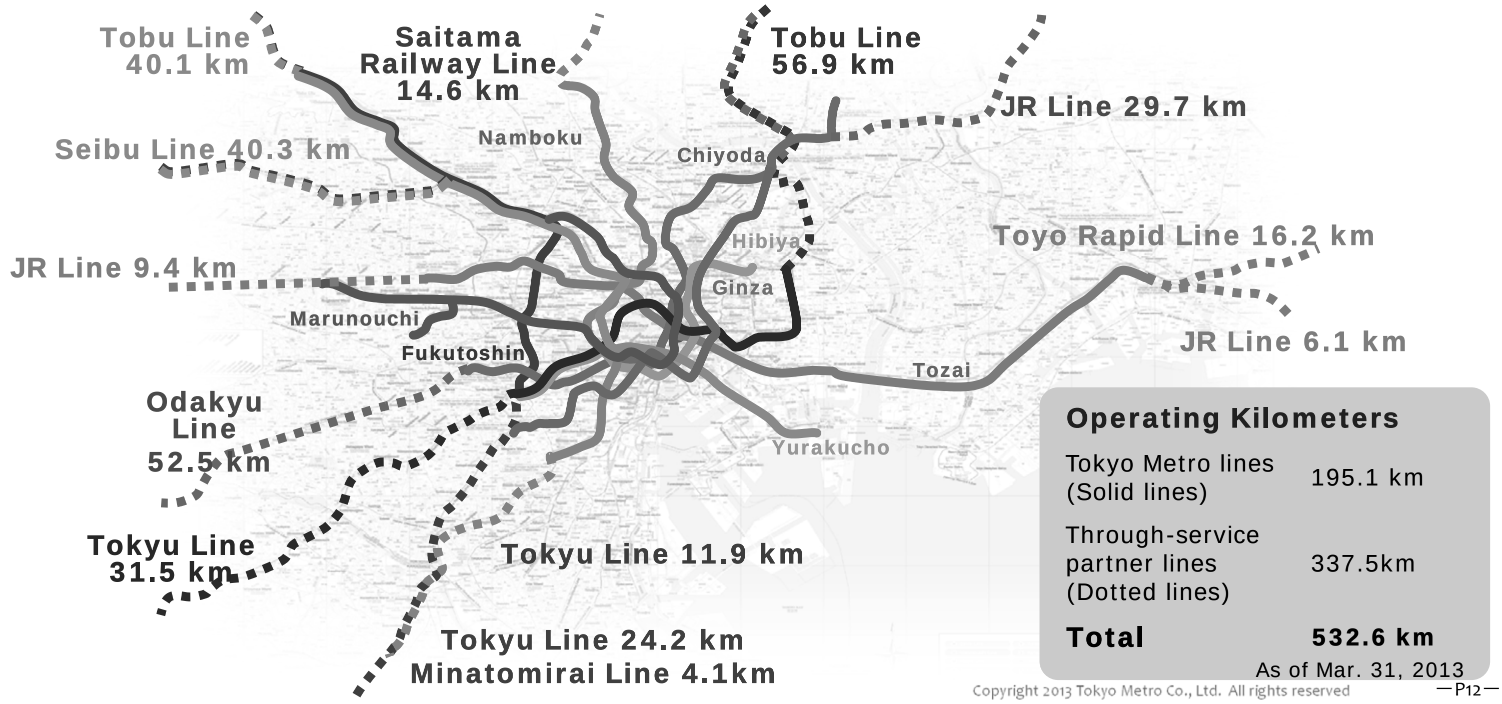
Tokyo Metro Vision

In stations

Marunouchi line "Station Vision"

Succeeded in bring passengers into the city center from the suburbs by creating a seamless ride (transfer not necessary)

- Eliminating the transfer from other transport modes, and improving conveniences such as direct connections with buildings above, have been the key points in attracting more passengers to the subway



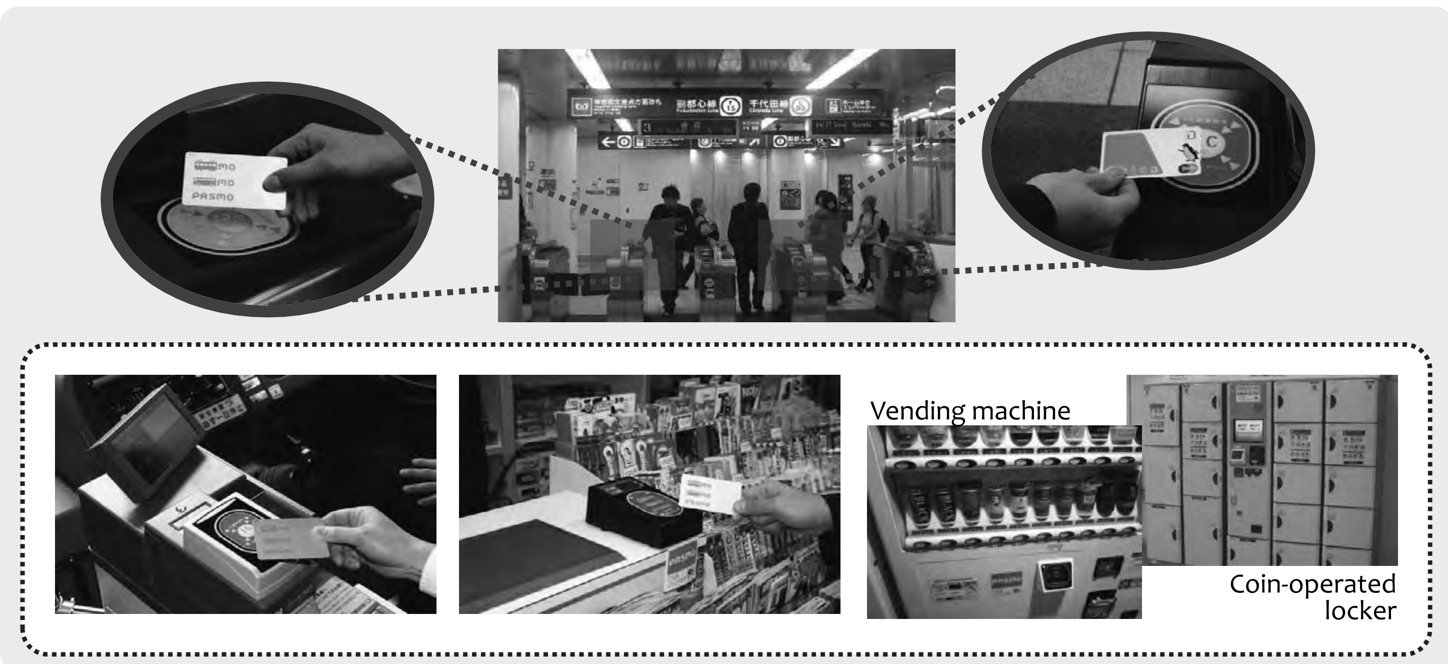
Operating Kilometers

Tokyo Metro lines (Solid lines)	195.1 km
Through-service partner lines (Dotted lines)	337.5km
Total	**532.6 km**

As of Mar. 31, 2013

-IC card system (PASMO)

- One IC card is interoperable with railways throughout Japan
- It also can conveniently be used for shopping



-Best practice (3) Ingenuity in company operation

-Operation using fare revenue (fare system approved by government)

- Succeeded in self-reliant efforts such as improvement of passenger service, reducing construction and operation cost

-The railway business is comparatively loosely regulated (Ex. business plans do not require approval from the central government, but must be reported)

- Autonomy of management was born, leading to ingenious efforts toward safe and stable operation, improvement of passenger service, creating comfortable underground (station) space etc.

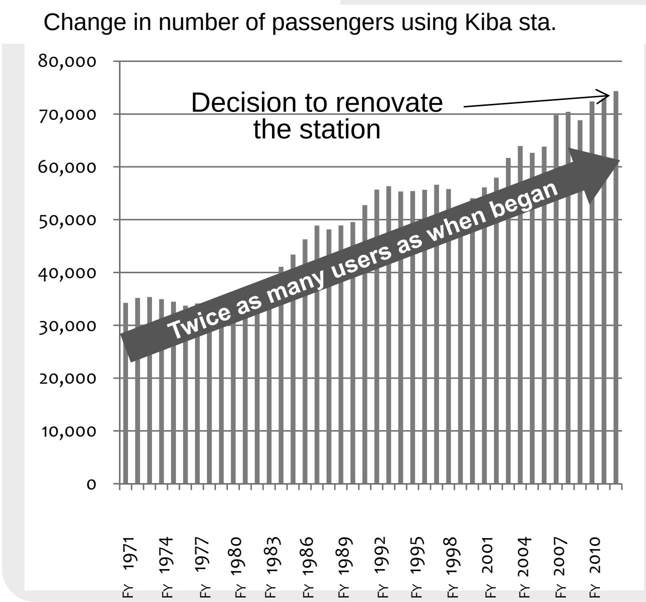
Utilizing awareness and proactivity as a private entity

-Learning from mistakes (1) Railway business facilities

-It is extremely difficult to expand space and install new facilities in the subway(due to the immense cost, lengthy construction period while still continuing train operations)

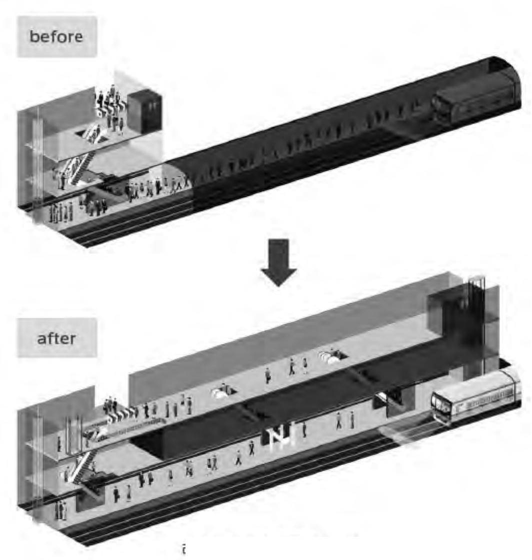
- Construction incorporating future demand (town development) and changes in social environment
- Facilities should be installed with as much leeway as possible, keeping in mind handling emergencies, inspection for maintenance, and facility upgrade

Renovation at Kiba sta. on the Tozai line



Increase in number of passengers exceeded the estimates at the time operation began, due to development of the area along the line
⇒Congestion on platform and concourse

Expansion of platform and concourse, as well as improvements in safety and convenience, such as installation of elevators and escalators



2. Tokyo Metro's Experience - Best practice and Learning from mistakes
- Learning from mistakes (1) Railway business facilities

Renovation of Minami-sunamachi sta. on the Tozai line

Existing facilities

Due to development along the Tozai line, the number of passengers increased and delays ballooned

New tracks and a new platform have been installed in order to prevent delay and improve safety

Installation of barrier-free facilities

There are not enough barrier-free facilities on the older lines

Station space is limited and it is difficult to obtain the necessary land above ground due to urbanization of Tokyo

Despite these severe constraints, we have made various creative adjustments in order to secure space for at least one barrier-free route from the platform to ground level

2. Tokyo Metro's Experience - Best practice and Learning from mistakes
-Learning from mistakes (2) Proactive development of related businesses

Due to strict regulation of related business up until the mid 1980's …

・Space purchased during construction was the minimal absolute necessary

・Station facilities installed not supposing future development of related business

(Kiosks and vending machines were installed in stations with limited space, along with advertisements)

<u>-It is important to make use of station concourse and station space to expand related businesses in order to improve the convenience of railway users and entice more people to use the subway</u>

<u>-Also, related business development contributes to the variance on risk management</u>

➢Promote development of stations that can have related businesses expanded in them from the very beginning

➢Enterprise to have assets where related businesses can be expanded freely in the future (land close to entrances/exits and land that was once used for material storage during construction)

2. Tokyo Metro's Experience - Best practice and Learning from mistakes
-Learning from mistakes (2) Proactive development of related businesses

■Metro Stage (Rental condominium)

Effective use of land that had once been used for storing materials during construction

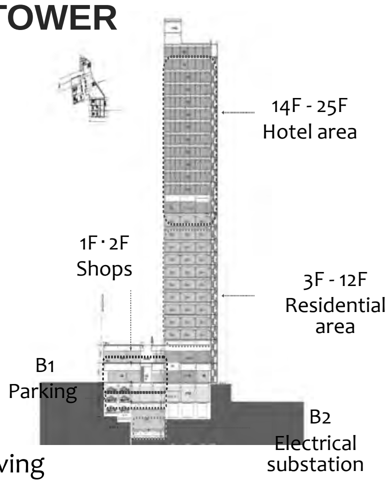
■Echika

Space in stations made available through large-scale renovation and reorganizing facilities

■Belle Vie Akasaka

Effective use of available land above a station

■AOYAMA M's TOWER



Effective use of space by moving substation underground

Thank you for your attention.

Appendix 8-7-4

Incentive Policies Supporting Sustainable Fare Structure for Hanoi Metro

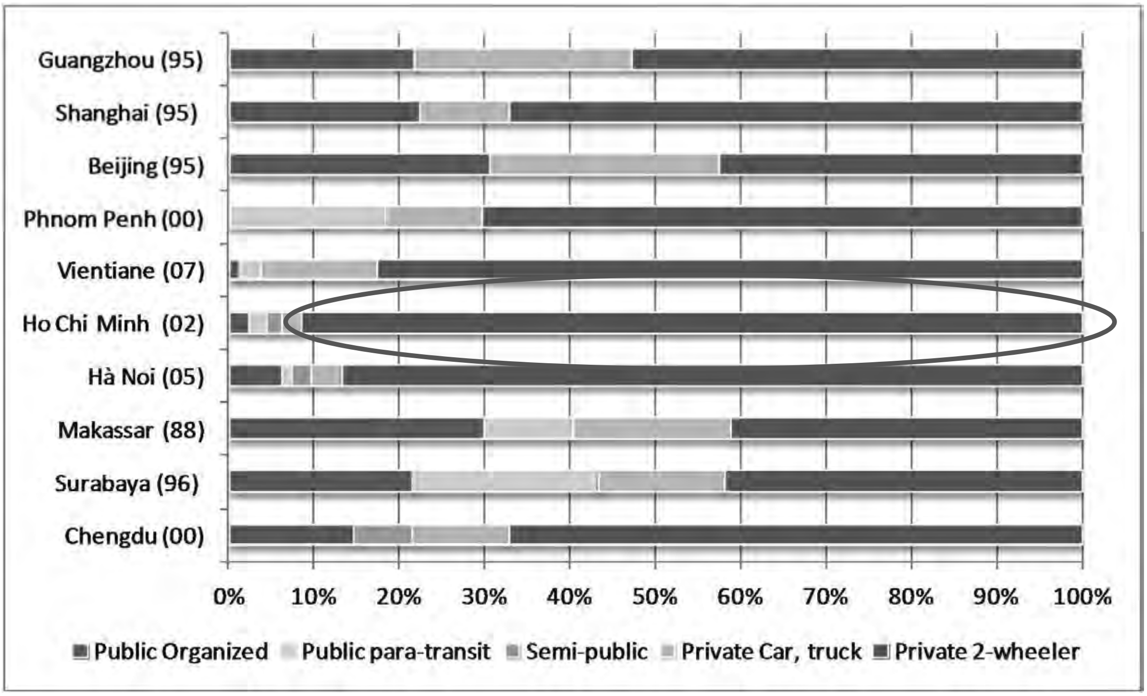
June 24^{th} 2014

Tetsuro HYODO
Professor
Tokyo University of Marine Science & Technology

by Koizumi, Nishimiya & Kaneko (2013)

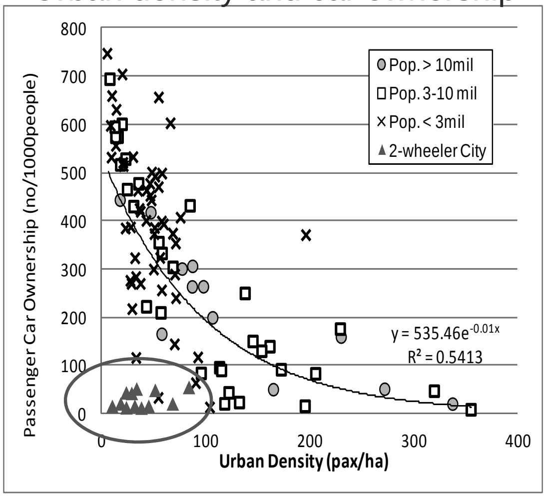
Two-wheeler Cities

In some Asian cities, two wheeler is the largest modal share.
⇒ It is defined as "two-wheeler cities"

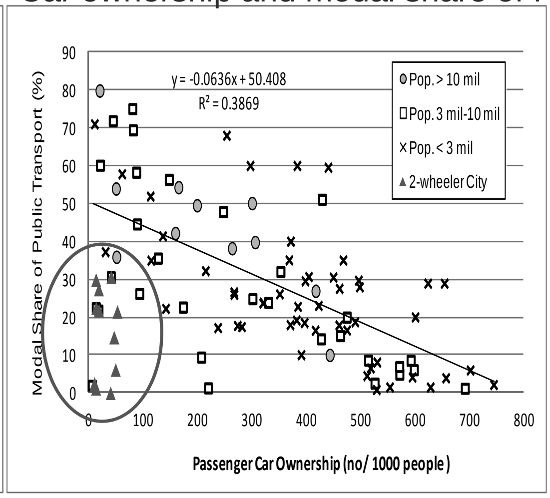


Characteristic of Two-wheeler Cities

Urban density and car ownership

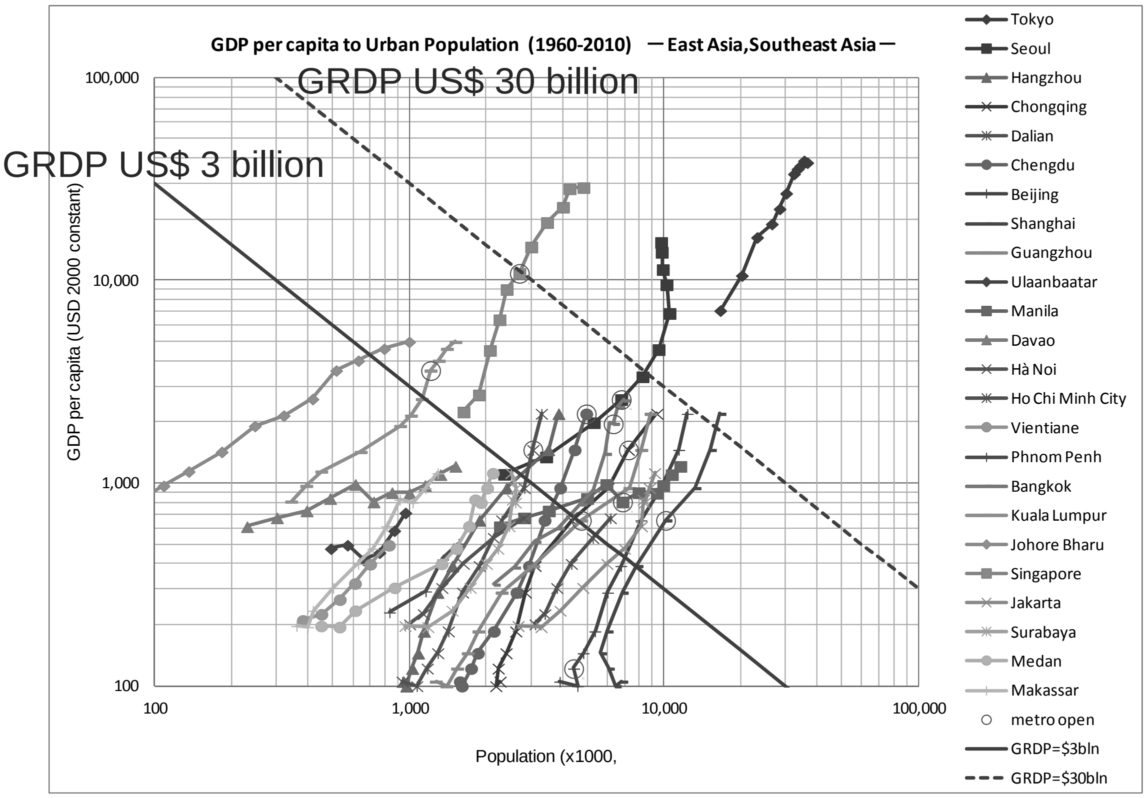


Car ownership and modal share of PT



Urban and transport indices of two wheeler cities are examined in the comparative perspective with the findings about 100 global cities.

Metro Operation Relative to GDP per capita and Urban Population Size



Contents:

1. Necessity of Regulation / Incentive at Monopoly Market

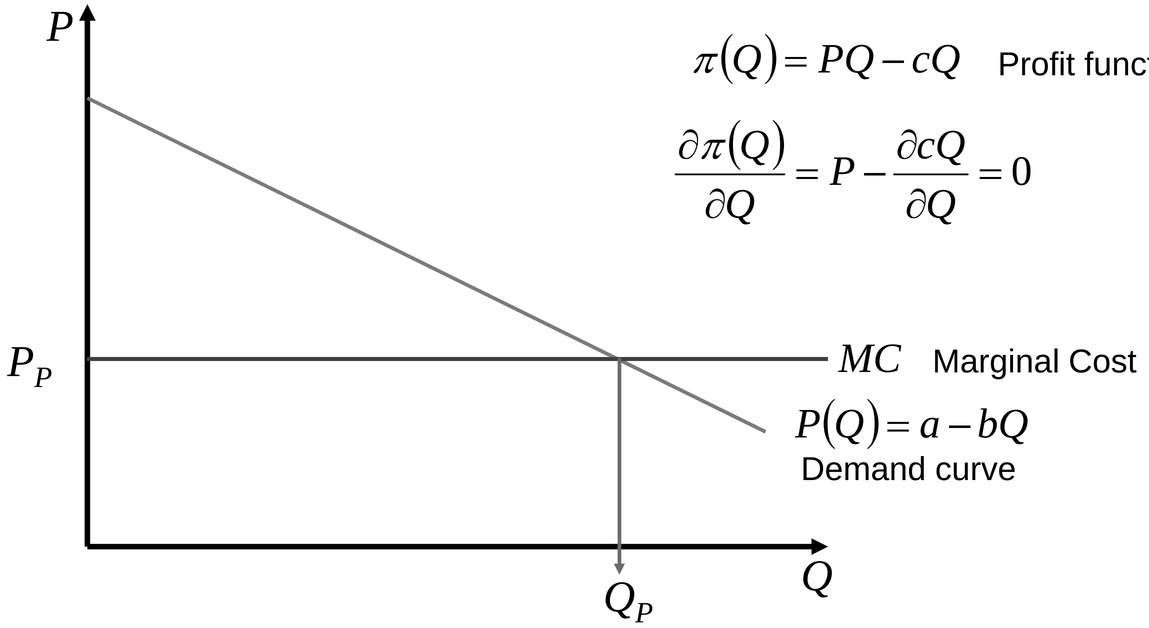
- Monopoly occurs when one firm can supply the entire market at a lower price than two or more firms can.
- Railway firms, Electricity firms, Gas firms…
  They need huge initial cost, so there are serious "Entry barriers".
- The barriers derives Monopoly market.

Case of “Perfect Market”, price is determined through the competition among many firms.

→ Firms is **“Price Taker”**

$$\pi(Q) = PQ - cQ$$ Profit function

$$\frac{\partial \pi(Q)}{\partial Q} = P - \frac{\partial cQ}{\partial Q} = 0$$

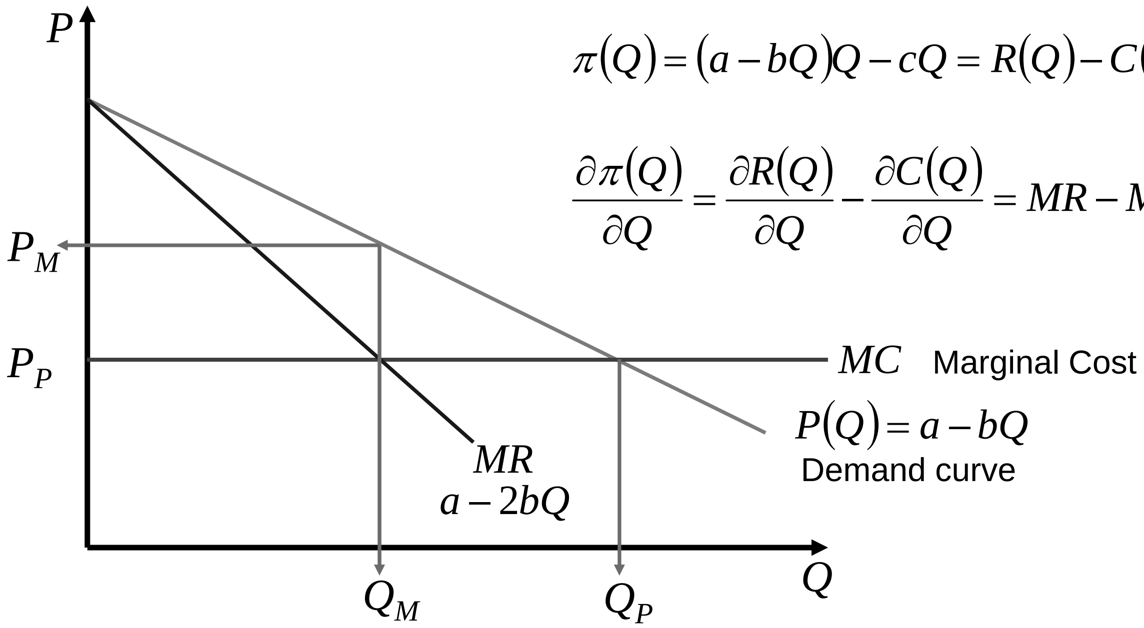


Case of “Monopoly Market”, price is determined by monopoly firm.

→ Firms is **“Price Maker”**

$$\pi(Q) = (a - bQ)Q - cQ = R(Q) - C(Q)$$

$$\frac{\partial \pi(Q)}{\partial Q} = \frac{\partial R(Q)}{\partial Q} - \frac{\partial C(Q)}{\partial Q} = MR - MC = 0$$



$\boxed{P_M > P_P}$ $\boxed{Q_M < Q_P}$

How to avoid the “Monopoly Price / Quantity”

- Regulations by public sectors
  → Public sectors control the appropriate price
  → However, they don’t have enough information: such as demand/supply curve
- Monopoly firms should decide price with keeping the “**Incentive** for efficient management”

Representative Incentive Policies

1) Price Cap

A price-cap regulation is a price ceiling—a rule that specifies the highest price the firm is permitted to set. Price cap regulation gives managers an incentive to minimize cost because there is no limit on the rate of return they are permitted to earn.

Price Cap Method

$$\boxed{\text{Price Increase Rate}} \leqq \boxed{\text{Inflation Rate}} - \boxed{\text{Cost down by innovation}}$$

2) Yardstick regulation

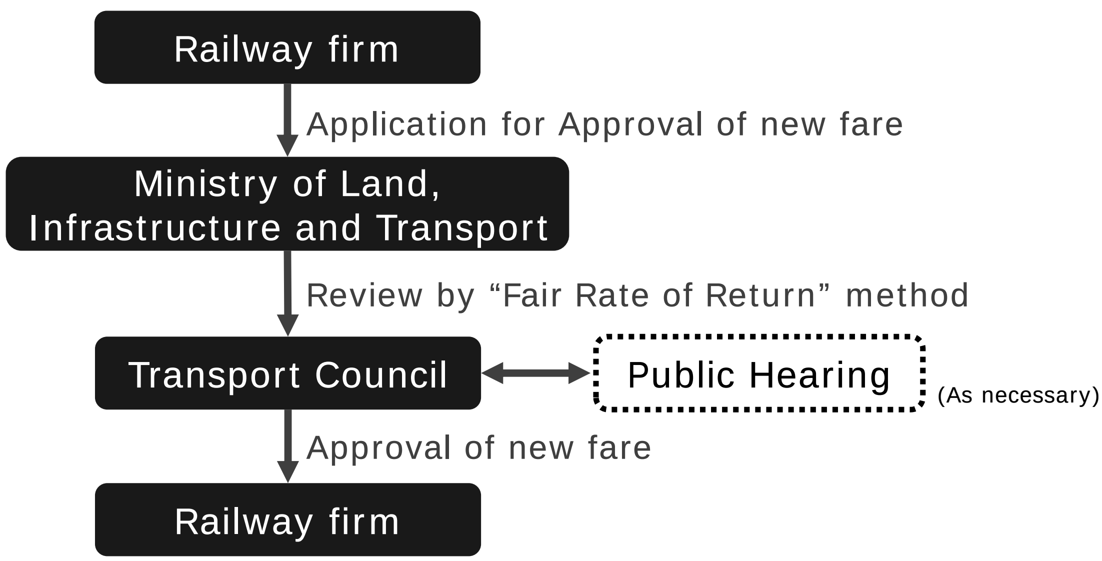
In the yardstick regulation the performance of a regulated utility is compared against of a group of comparable utilities: for example, the mean of the costs of a peer group of firms can serve as performance

→ Public sector should collect the cost information of peer firms, and open the statistics.

→ The lowest cost is selected as the yardstick and prices (fares) lower than the yardstick is approved.

2. "Yardstick regulation" for Japanese Railway

- The current system started in 1997.
- Process:



Calibration of "Standard Cost" [case of metro]

1) Rail Track Cost [cost/km]

$y_1 = a_1(\ln[\text{car density}]) + c_1$

2) Cable Run Cost [cost/cable km]

$y_2 = a_2(\text{car density}) + b_2(\text{ratio of cable run}) + c_2$

3) Car Cost [cost/car] → "maintenance cost"

$y_3 = a_3(\text{\# of passengers/car}) + c_3$

4) Car Operation Cost [cost/operating km]

$y_4 = a_4(\text{ratio of "one-man" operation}) + b_4(\ln[\text{car density}]) + c_4$

5) Station Service Cost [cost/station]

$y_5 = a_5(\ln[\text{\# of passengers/station}]) + c_5$

a) "Standard Cost" calibrated by three groups

1) "JR companies" [6]

2) "Major Private companies" [15]

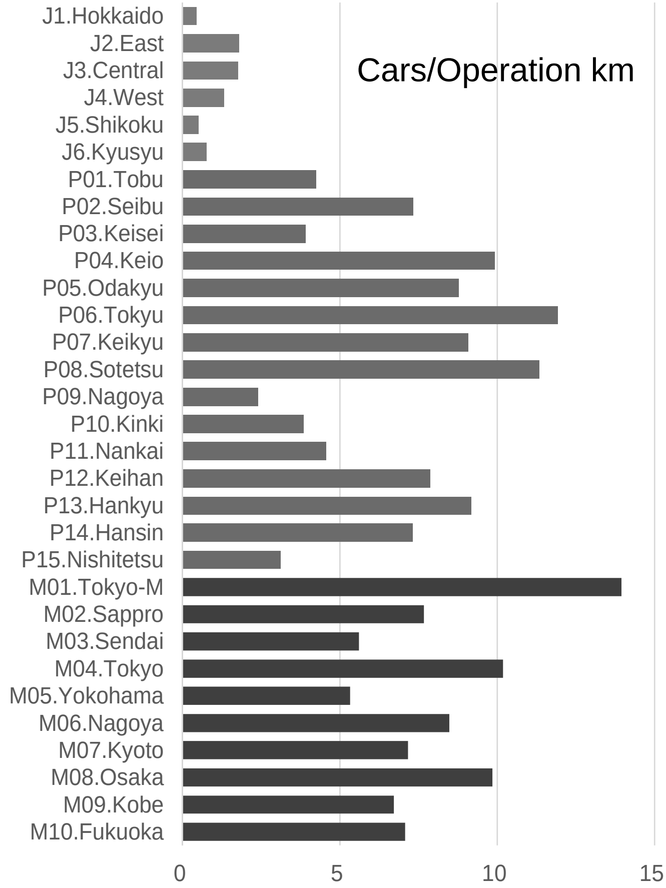
3) "Metros" [10]

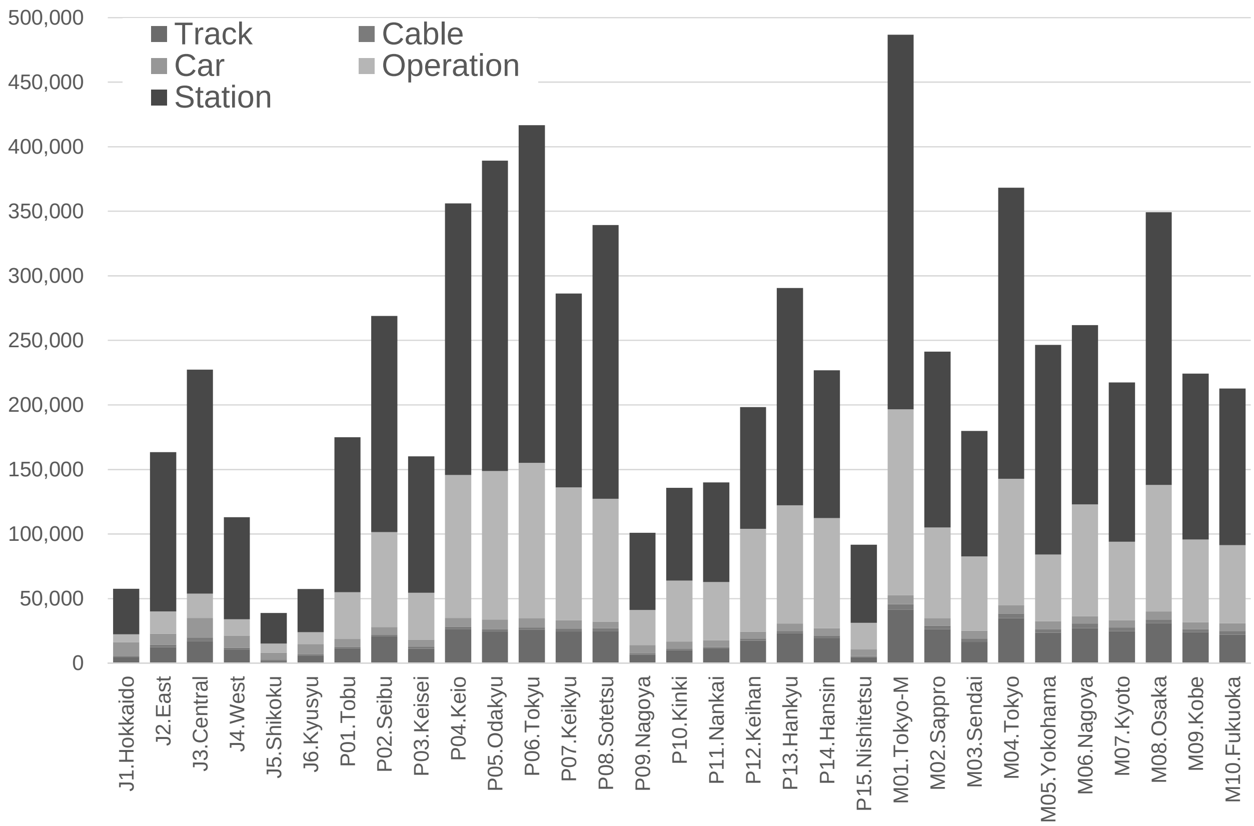
b) Parameters (a., b., c.) are updated every year by using the latest 3 years data reported by each company.

c) MLIT (Ministry of Land, Infrastructure and Transport) has conducted all procedures and made public the results every summer.

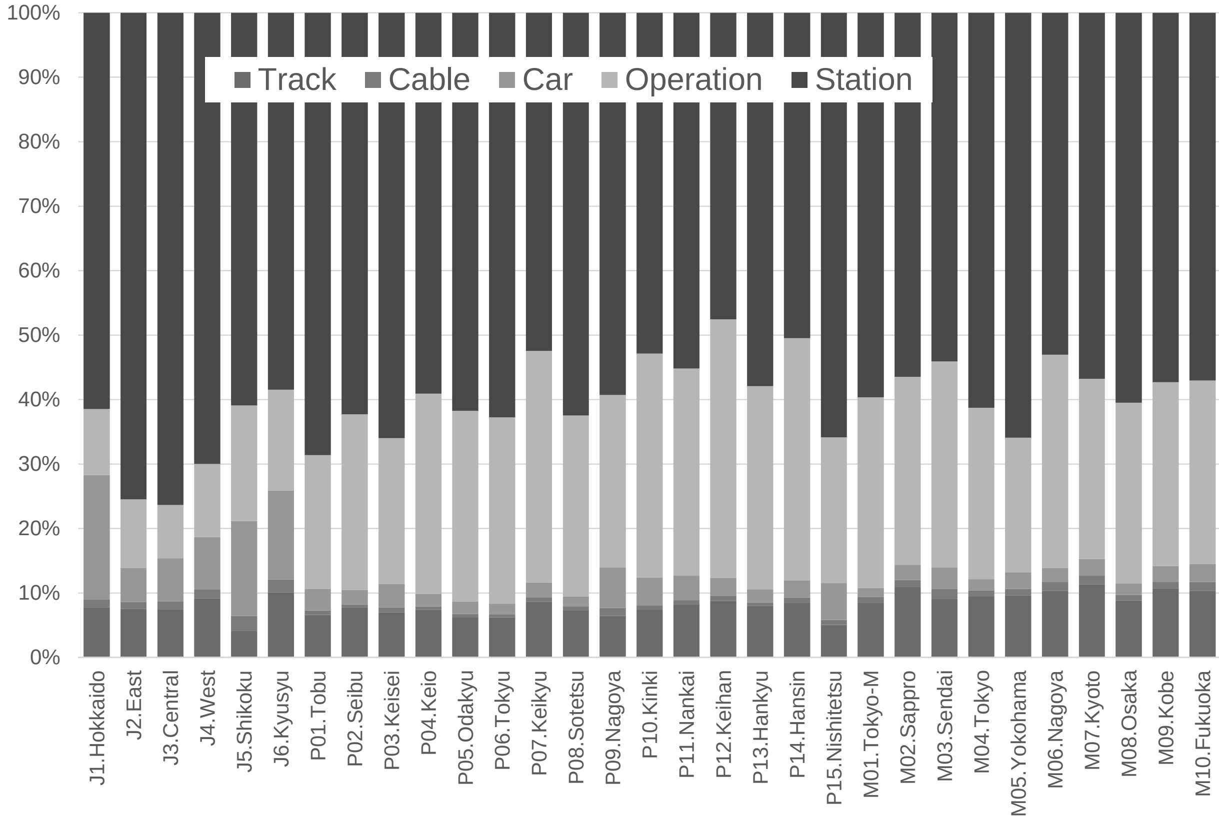
Basic Stat of Japanese Major Railway Companies

	# of Cars	Operation km	# of Stations
J1.Hokkaido	1,095	2,500	465
J2.East	13,469	7,513	1,688
J3.Central	3,465	1,971	409
J4.West	6,534	4,992	1,222
J5.Shikoku	427	855	259
J6.Kyusyu	1,704	2,273	566
P01.Tobu	1,960	463	203
P02.Seibu	1,274	174	91
P03.Keisei	594	152	69
P04.Keio	843	85	69
P05.Odakyu	1,061	121	70
P06.Tokyu	1,252	105	97
P07.Keikyu	790	87	73
P08.Sotetsu	408	36	25
P09.Nagoya	1,060	444	275
P10.Kinki	1,934	505	288
P11.Nankai	702	154	99
P12.Keihan	716	91	87
P13.Hankyu	1,319	144	89
P14.Hansin	358	49	51
P15.Nishitetsu	329	106	72
M01.Tokyo-M	2,719	195	179
M02.Sappro	368	48	49
M03.Sendai	84	15	17
M04.Tokyo	1,110	109	106
M05.Yokohama	282	53	42
M06.Nagoya	788	93	100
M07.Kyoto	222	31	32
M08.Osaka	1,280	130	123
M09.Kobe	208	31	26
M10.Fukuoka	212	30	36

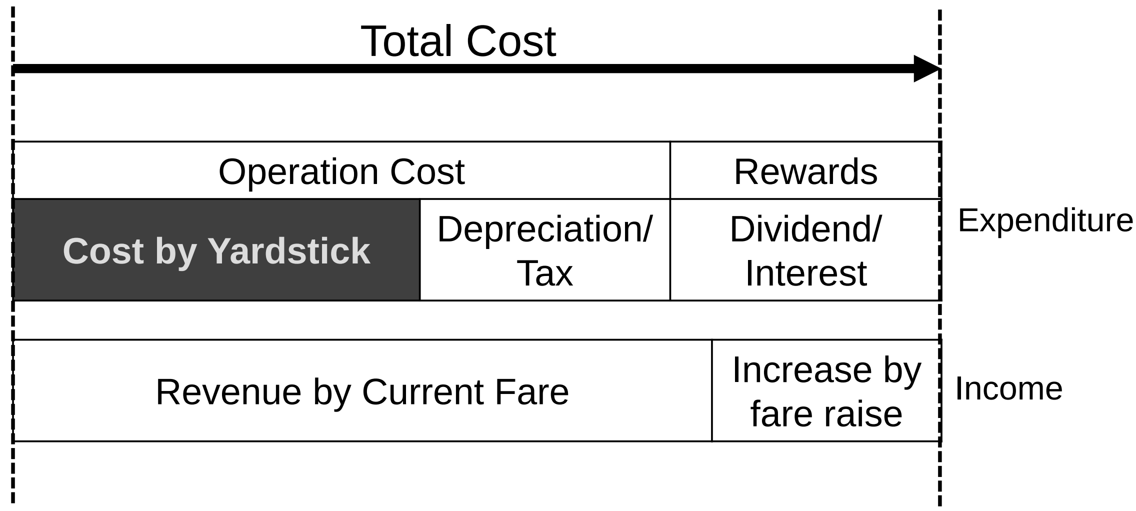




Calibrated 5 cost factors by each company [2012 stat.]



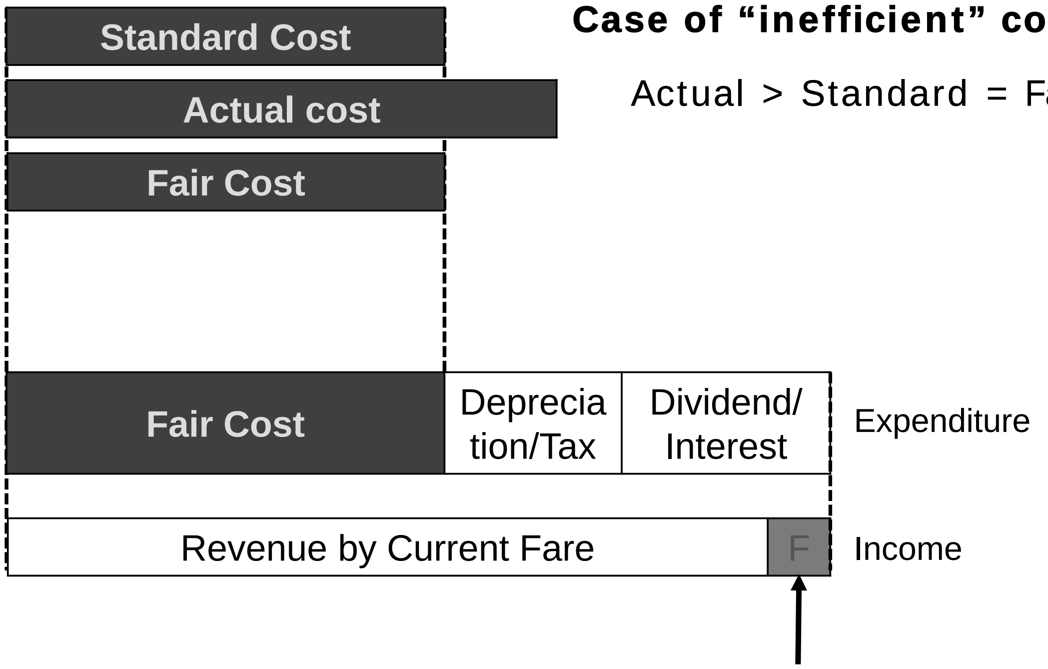
Calibrated 5 cost factors by each company [2012 stat.]



- Average “Cost by Yardstick” are as follows:
  a) JR: 42%, b) Major Private: 52%, c) Metro: 51%
- “Fair Cost” is derived from the difference between “Standard Cost” and “Actual Cost” (reported by companies)

Case of “inefficient” company

Actual > Standard = Fair Cost

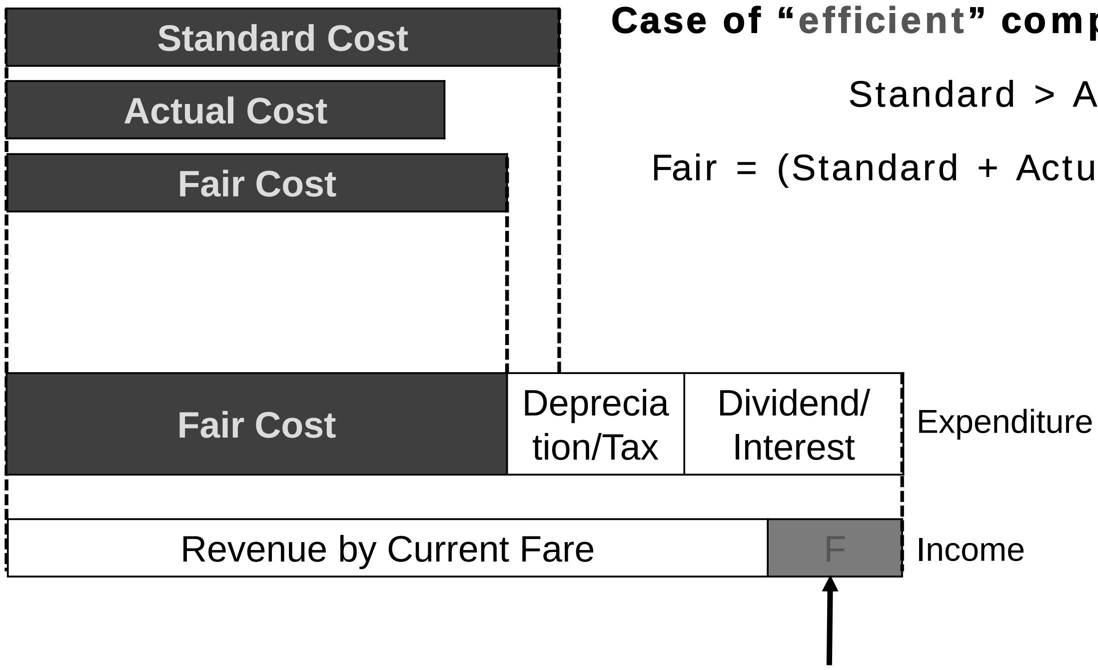


Portion for Fare raise is small !

Case of “efficient” company

Standard > Actual

Fair = (Standard + Actual)/2



Portion for Fare raise is large !

Efficiency Statistics

(Standard Cost - Actual Cost) / Actual Cost

"+"→ efficient, "-"→ inefficient

	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
J1.Hokkaido	-0.031	0.087	0.063	0.078	0.030	-0.059	0.112	0.047	0.097	0.003	0.058	0.021
J2.East	-0.062	-0.050	-0.067	-0.056	-0.040	-0.059	-0.026	-0.044	-0.052	-0.031	-0.016	-0.056
J3.Central	0.029	0.054	0.042	0.042	0.017	-0.001	0.014	0.028	0.037	0.025	0.012	-0.019
J4.West	-0.002	0.003	-0.021	-0.033	-0.036	-0.047	-0.018	-0.009	-0.008	0.037	0.030	0.003
J5.Shikoku	0.106	0.092	0.065	0.021	-0.022	0.015	0.024	0.039	0.053	0.006	-0.009	-0.051
J6.Kyusyu	0.025	0.089	0.075	0.122	0.097	0.158	0.108	0.104	0.049	0.057	0.135	0.101
P01.Tobu	-0.076	-0.068	-0.022	-0.033	-0.068	-0.070	-0.035	-0.034	-0.012	-0.033	0.009	0.013
P02.Seibu	0.053	0.049	0.071	0.021	0.021	0.002	-0.015	0.025	0.074	0.070	0.081	0.106
P03.Keisei	-0.016	-0.045	-0.043	-0.052	-0.056	-0.064	-0.041	0.000	0.000	-0.005	-0.007	-0.020
P04.Keio	0.063	0.005	-0.017	-0.067	-0.044	-0.039	-0.017	-0.035	-0.020	-0.018	-0.010	0.000
P05.Odakyu	-0.041	-0.018	0.053	0.036	0.035	0.072	0.089	0.089	0.058	0.060	0.071	0.050
P06.Tokyu	0.065	0.100	0.013	0.067	0.038	0.024	0.006	0.028	0.015	-0.002	-0.017	-0.010
P07.Keikyu	-0.010	-0.051	-0.065	-0.079	-0.093	-0.107	-0.121	-0.108	-0.130	-0.150	-0.132	-0.112
P08.Sotetsu	-0.060	-0.066	-0.069	-0.040	-0.013	-0.004	-0.025	-0.074	-0.062	-0.019	-0.049	-0.057
P09.Nagoya	0.032	0.008	0.068	0.074	0.098	0.089	0.110	0.080	0.068	0.145	0.101	0.119
P10.Kinki	-0.032	-0.013	0.036	0.073	0.062	0.097	0.086	0.066	0.046	0.057	0.067	0.047
P11.Nankai	-0.038	0.001	-0.053	-0.069	-0.078	-0.050	-0.062	-0.064	-0.095	-0.068	-0.063	-0.081
P12.Keihan	-0.009	0.049	-0.029	0.012	-0.020	-0.041	-0.055	-0.054	0.004	0.000	-0.021	-0.043
P13.Hankyu	-0.033	-0.011	0.055	0.082	0.089	0.087	0.086	0.111	0.084	0.088	0.080	0.063
P14.Hansin	0.118	0.096	0.058	0.041	0.055	0.067	0.071	0.067	0.054	0.011	0.016	0.011
P15.Nishitetsu	0.064	0.006	0.005	0.022	0.091	0.051	0.031	-0.011	-0.002	-0.016	-0.050	-0.015
M01.Tokyo-M	-0.046	-0.075	-0.030	0.020	-0.005	0.008	-0.003	-0.018	-0.029	-0.024	-0.029	-0.021
M02.Sappro	0.024	0.088	0.067	0.081	0.148	0.152	0.189	0.136	0.113	0.104	0.132	0.114
M03.Sendai	0.053	-0.025	-0.050	-0.036	-0.057	-0.089	-0.078	-0.093	-0.164	-0.153	-0.230	-0.123
M04.Tokyo	0.076	0.127	0.106	0.088	0.036	0.018	0.002	-0.009	-0.025	-0.068	-0.065	-0.061
M05.Yokohama	0.069	0.081	0.077	0.144	0.142	0.184	0.137	0.246	0.242	0.235	0.256	0.293
M06.Nagoya	0.134	0.220	0.186	0.094	0.122	0.154	0.144	0.138	0.126	0.068	0.116	0.079
M07.Kyoto	-0.166	-0.166	-0.094	-0.131	-0.168	-0.182	-0.174	-0.147	-0.116	-0.043	-0.006	0.003
M08.Osaka	-0.172	-0.144	-0.114	-0.122	-0.107	-0.093	-0.062	-0.055	-0.060	-0.068	-0.112	0.016
M09.Kobe	0.078	-0.003	0.042	0.023	0.116	0.086	0.064	0.062	0.036	0.044	0.031	0.012
M10.Fukuoka	0.137	0.126	0.117	0.154	-0.002	-0.019	-0.003	-0.009	-0.040	-0.028	-0.008	-0.010

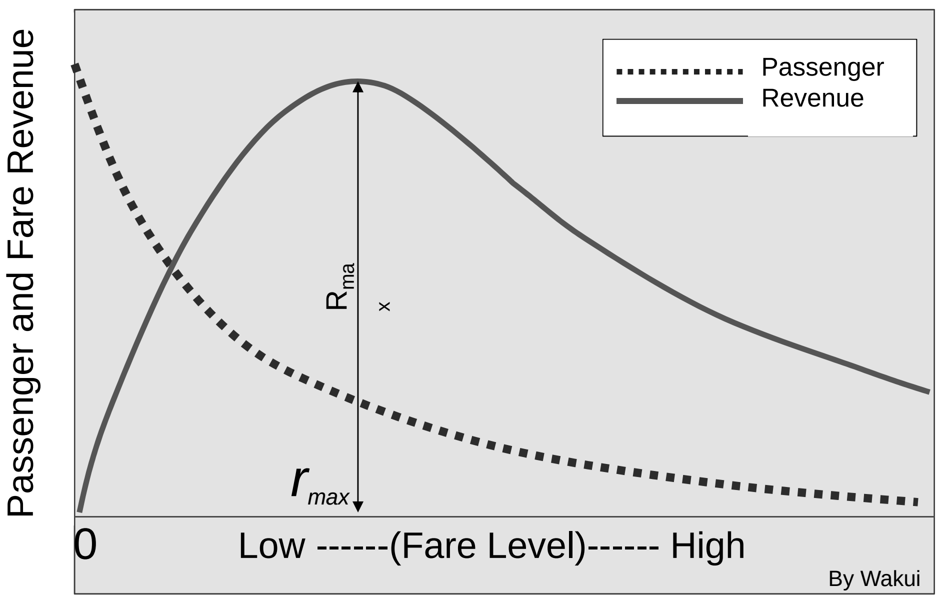
3. Remarks on Fare Structure of Hanoi Metro

- Hanoi Metro should be profitable firm

  → Financially Independent

- Low Fare (High Social Benefit) vs.

  High Fare (Generating Profit)



- How to balance between other modes

Income level	Competitor
High	Private Car
Middle	Motorcycle
Low	Bus

- Majority in Hanoi is **Motorcycle!**
  → very difficult to switch from Motorcycle to Metro (regarding travel time, travel cost & free to move)
- However, price competition with other modes should be avoided (especially with Bus!)
  → Principle of **"Financially Independent"**

Cost/ Revenue/ Subsidy of Bus Service in Hanoi

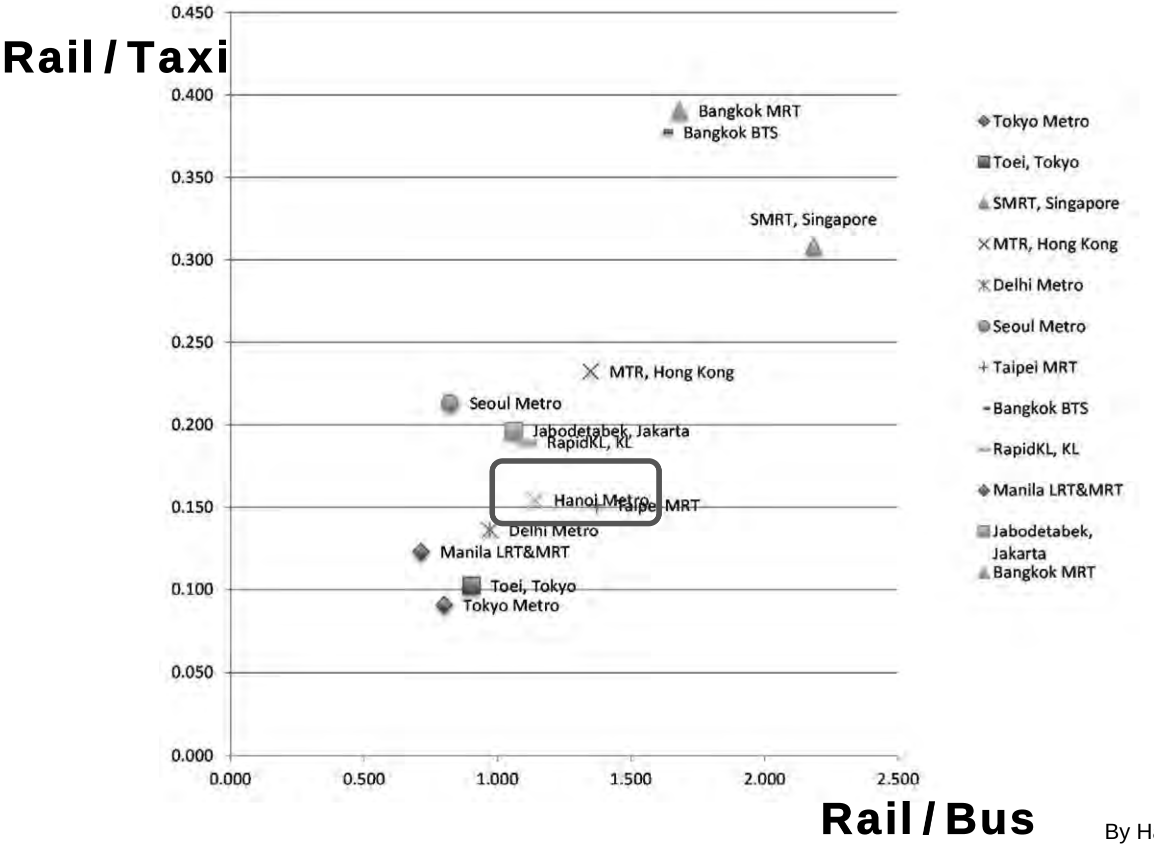
Item	Unit	**2006**	**2007**	**2008**	**2009**	**2010**
Revenue	million vnd	308,679	329,232	372,629	383,949	395,936
Subsidy	million vnd	203,183	236,955	440,425	424,807	620,867
Expense	million vnd	506,749	566,521	813,054	808,756	1,016,804
Revenue/Expense	%	60.9	58.1	45.8	47.5	38.9
Subsidy/ Expense	%	40.1	41.8	54.2	52.5	61.1

Source: TRAMOC

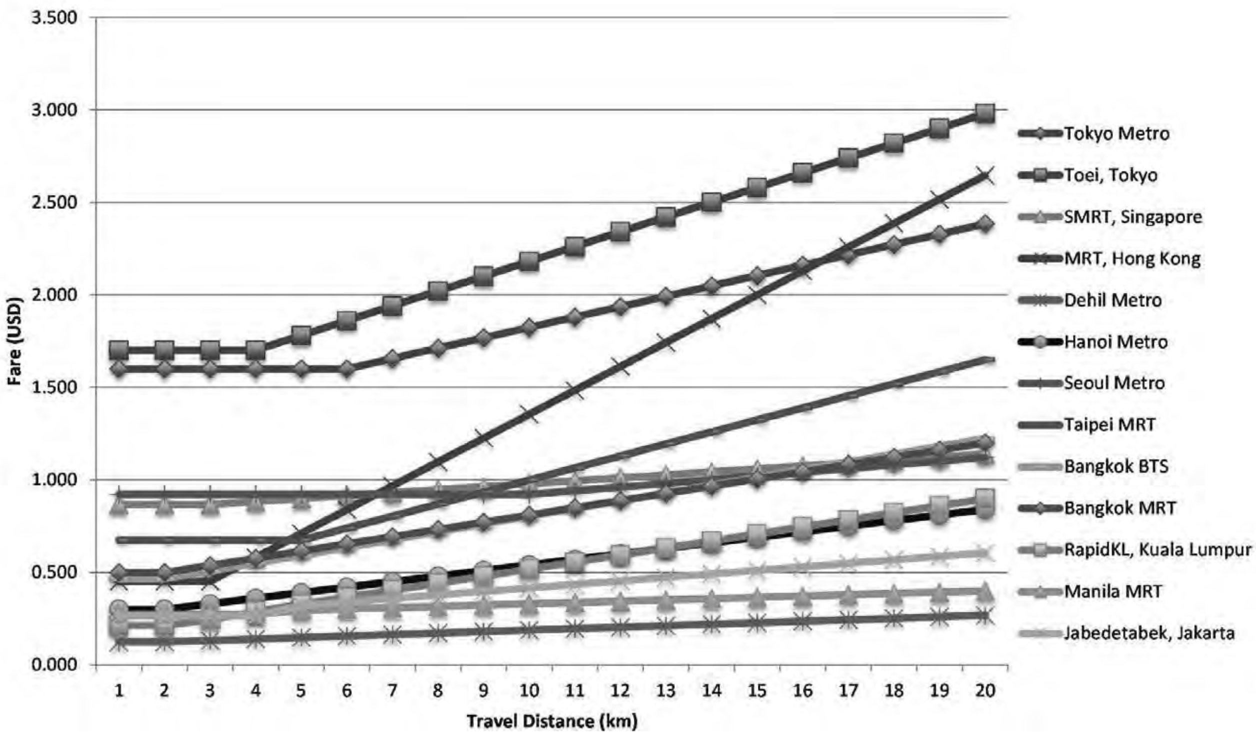
Busses can be sustainable without subsidy, provided the fare is 2.5 times of the present , that is, by raising from vnd 5,000 /ride to vnd 15,000 /ride.

By Wakui

Fare Ratio of Rail / Bus / Taxi



Fare Level by Distance



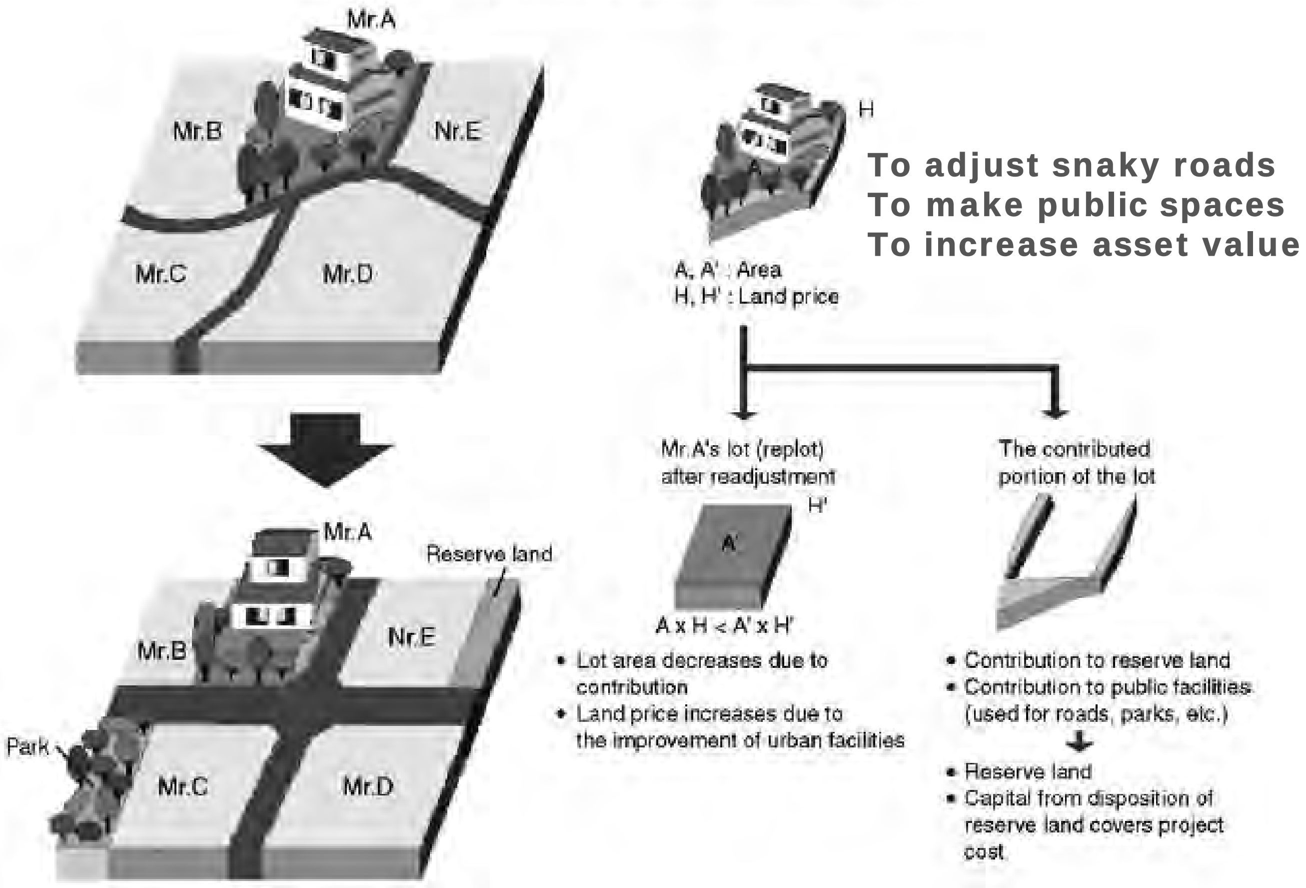
4. Legal System for Transportation / Land-Use Development (Case in Japan)

How to produce spaces for transportation facilities or public spaces

Comparison of Urban Development Projects Systems in Japan

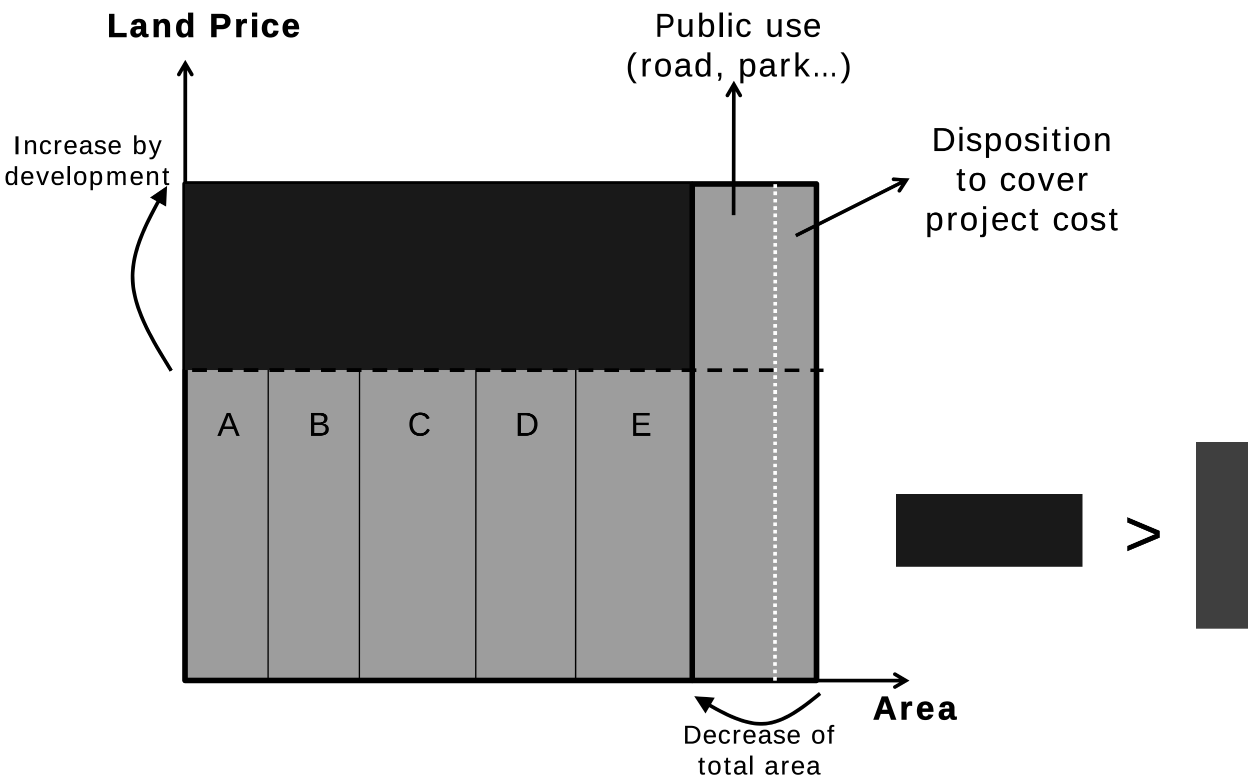
Name of Systems	Land Readjustment Project	Urban Redevelopment Project	New Residential Area Development Project
Measure	Replotting[1] (Exchanging Rights from One Land to Another)	Right Conversion[1] (Exchanging Rights from a Land to a Building Floor)	Whole Purchase Including the Right of Compulsory Expropriation
Objective	Development of Public Facilities Increase of Use in Building Lots	Development of Fire-resistant Building Development of Public Facilities Rational and Sound High Utilization of Land	Planned development of new built-up area by single implementing body.
Legal Basis	Land Readjustment Law (1954)	Urban Redevelopment Law (1969)	New Residential Area Development Law (1963)
Target Areas	Applied Broadly from Urbanized Area to New Town	Urbanized Area	New Town
Project Size	Usually more than a few ha	Several ha. (Mainly 1-3 ha)	More than 100ha
Implementing Bodies	Individuals, Cooperatives, Local governments, Public Corporations[2]	Individuals, Cooperatives, Local governments, Public Corporations[2]	Local Governments, Public Corporations
Achievement[3]	395,206 ha	1,193 ha	17,943 ha

Figure 8-2 Framework of Land Readjustment Project



To adjust snaky roads
To make public spaces
To increase asset value

Space-Value Relation of Land Readjustment



Japanese experience for coordinated development of
"railway & residential area",
"railway company & local government"

Case of TSUKUBA EXPRESS

- Length: 60 km, 20 stations
- Max speed: 130 Km/h
- Average speed: 77 Km/h (45 min. for 60 Km)
- Frequency: 16 trains during peak hour
- Total construction cost: 8.2 Billion US$
- Term of Construction:
  → 1994 to 2005 (Operating from August 2005)

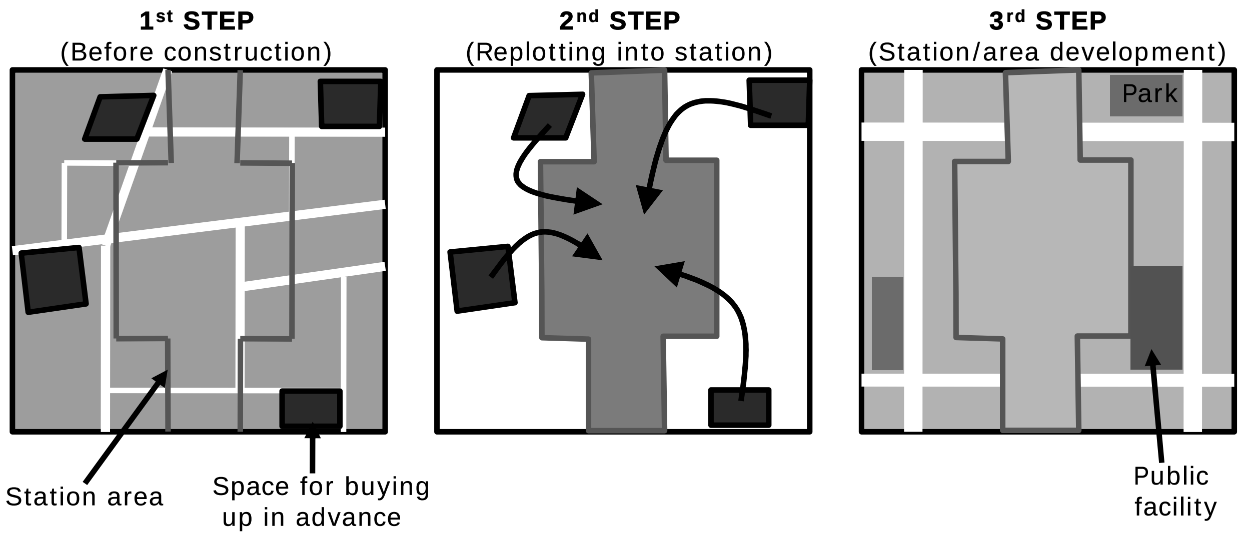
New law, “The Special Measures Law for Coordinated Development of Residential Areas and Railways in Metropolitan Areas” was approved and enforced in 1989 for the construction of “Tsukuba express”

Purpose of the law:

- for facilities simultaneous construction of railways and development of residential land for large housing projects
- to promote railway development hand-in-hand with development of land near the proposed right-of-way
- to promote simultaneous development of railway land, roads, parks, residential lands and other urban facilities
- The railway construction company and its partners in the public sector buy up land lots during the preliminary stage and these lots are finally assembled and/or substituted for other lots to create a contiguous stretch of land purchased by the railway operator

Kazunobu YAMADA (2005): “Tsukuba Express”, Japan Railway & Transport Review 42

Concept of Implementation of “New Law”



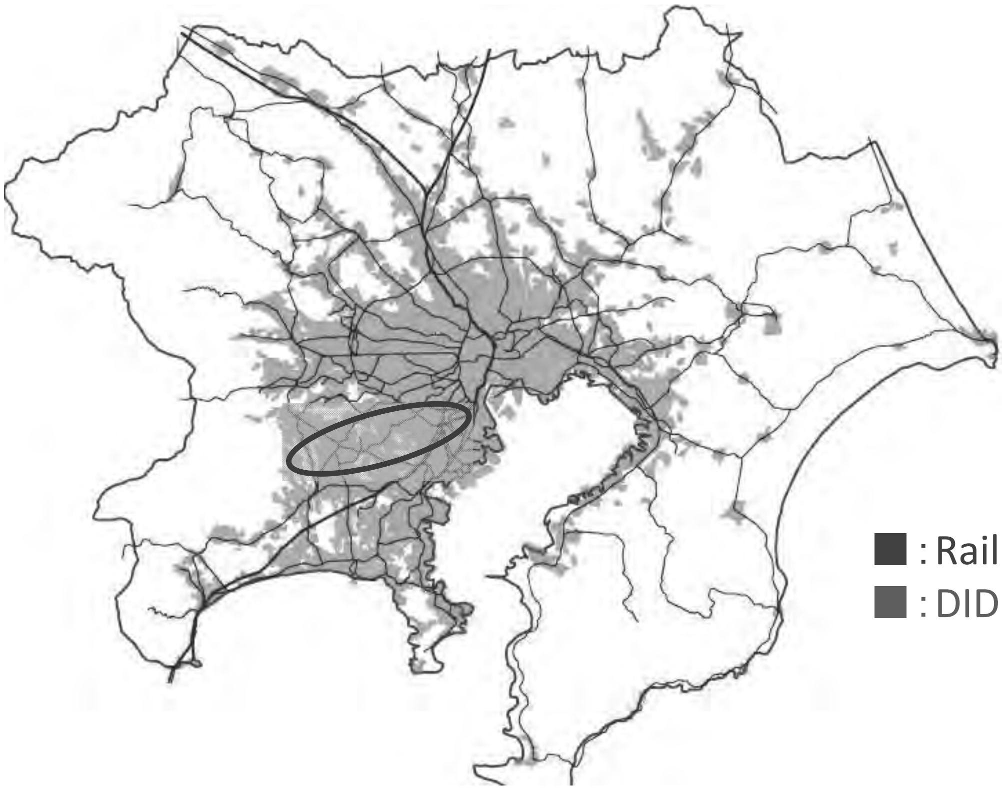
- Station area was decided
- Local government, railway company buy up lands near station to produce station/rail space

- The lands bought up are replotted into station/rail lots

- Completion of station, rail, roads, parks and other public facilities for better QOL !

- **Coordination for better space with station & residential area**
- **Coordination by railway company, local government and private sectors**
- **Coordination through efficient/equitable money flow**

Railway-Oriented Land Use Pattern in Tokyo Metropolitan Region



BUSINESS OPERATED BY PRIVATE RAIL COMPANY

TYPES OF BUSINESS OPERATED BY RAILWAY CONSORTIA AND THEIR AFFILIATED COMPANIES	
BUSINESS	**RANGE OF ACTIVITIES**
Transportation	**Railway operations; bus services; taxi services; car rentals; trucking; aviation; shipping; freight forwarding; package delivery; manufacturing of rolling stock**
Real Estate	**Construction, sale, and leasing of housing, office space, hotels; architectural and engineering services; landscaping**
Retailing	**Construction and operation of department stores; supermarket chains, station kiosks, catering services, and specialty stores**
Leisure and Recreation	**Construction and operation of resorts and spas, amusement parks, baseball stadia, multiplex movie theatres, fitness club, golf courses; operation of travel agencies**

THE TOKYU CORPORATION

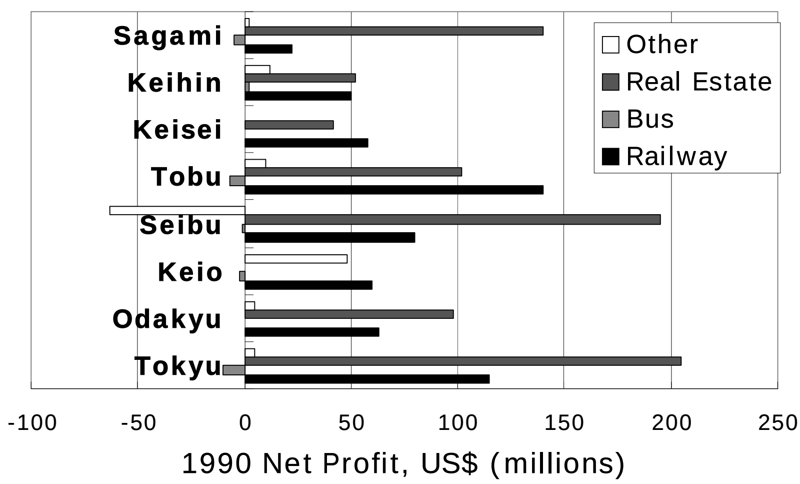
Tokyu Group

- **Transportation**: 66 companies including Tokyu Corp
- **Property Development**: 77 companies
- **Retailing and distribution**: 94 companies, 1 foundation
- **Recreation and leisure**: 146 companies, 1 foundation
- **Culture and education**: 7 companies, 8 foundations

- **The largest rail-based conglomerate in Japan**
- **Operates 7 main lines and one street car; in 1993, it served more than 961 million passengers which is larger than any other company**
- **In all, it owns 389 subsidiary business; in 1992 earned revenues exceeding $35 billion; capital assets worth more than $4 billion**

ECONOMICS OF PRIVATE RAILWAY INITIATIVES

- **Rail operations have hardly been the most profitable ventures of private rail companies**
- **Despite the government's fare regulation, all private rail companies made a profit; in 1993, all companies earned at least 30 percent return on real estate**
- **Other than rail services, Bus, Real Estate Development are among the major source of profits**



"Tama Hills" in Southwest Tokyo

- Before 1945, the Tama Hills, southwest of Tokyo were largely forested and occupied by small villages along an old trunk road.
- After World War II, many farmers migrated to the area.

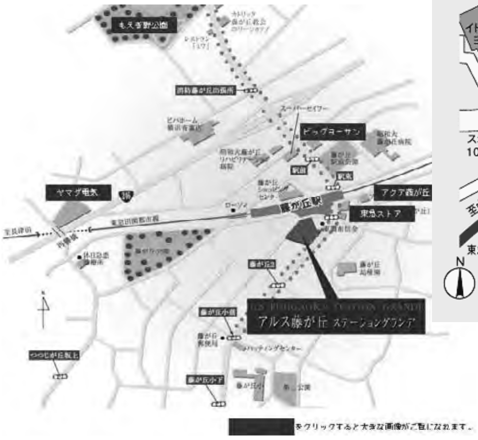
"Tama Garden City Plan" by *Tokyu Railway Company*

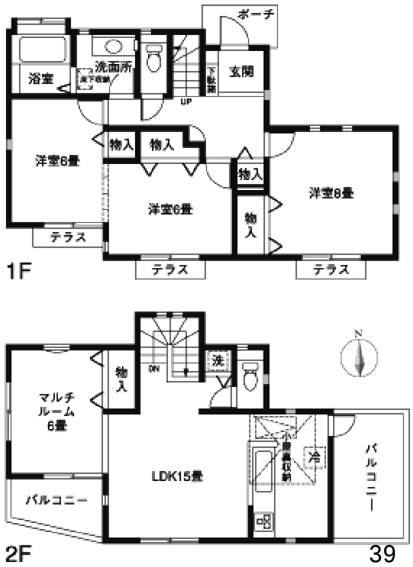
In 1953, Mr.Keita GOTO unveiled a *"new town"* planning scheme called the ***South-Western Area Development Plan***.

DESIGN OF TAMA DEN-EN TOSHI

- **Designed with two town centers and housing estates around the 19 stations along Tokyu's Denin Toshi rail line**
- **To jump start the construction, Tokyu sold land to public housing corporations**
- **Tokyu also builds pools, tennis courts, museum, and sports facilities to attract potential residents and sell housing at premium prices**
- **To attract big institutions, land were donated or sold below market value in return to generate development and ridership**

Advertising examples of real estates in Tama Den-en Toshi…





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