A Study of the Vehicle Maintenance Facilities Plan for the Urban Maglev Program in Korea

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ABSTRACT: This paper is a report on the Vehicle Maintenance Facilities Design Project of the Urban Maglev Program in Korea. The Vehicle Maintenance Facilities will play a very important role in the operation period of Urban Maglev commercial line in Korea. For the stable operation of Maglev vehicles, maintaining their good performance is a prerequisite condition. Maglev should be inspected and repaired periodically of their functions. Generally, the vehicle maintenance facilities are constructed near either the originating station or the termination station to minimize the time needed for vehicle maintenance. In this study, we will explain the current status of vehicle maintenance facilities, site selection, entrance & exit line, layout an stable line type of maintenance facilities, inspection building, reliability centered maintenance(RCM) plan, application of Maglev RAM data, vehicle maintenance process and introduction of the maglev maintenance information system(MMIS).

1 INTRODUCTION

This paper discusses the basic design result of the Maglev Vehicle Maintenance Facilities Design Project for the Urban Maglev program in Korea. Aimed growing demands of city commuters, urban maglev system is getting more attention because of various benefits such as reduction of traffic congestion, air and noise pollution, and financial costs. It is certainly uprising as a new transport model in the 21st century.

South Korea has the plans to commercialize its first urban maglev train in the following six years. According to the Urban Maglev in Korea, RFP(Request for Proposal) was issued in November 2006 and design and construction were planned to complete from December 2006 to December 2012. KRNA(Korea Rail Network Authority) has been developing and planning to construct a 6.113km commercial rail line by practical use.

The maglev commercial line is generally composed of main line guideway structure, rail system, electric installation, signaling, communication, stations, MVMF(Maglev Vehicle Maintenance Facilities), etc, and Maglev commercial line is shown in Figure 1.

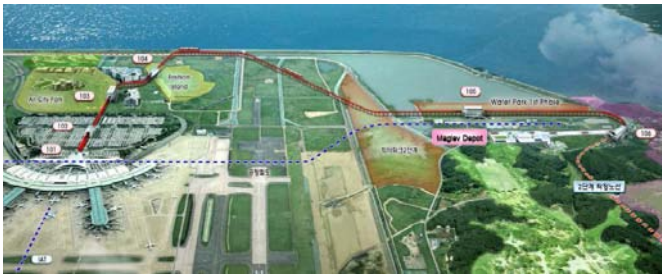

Figure 1. Commercial maglev line in Incheon International Airport, Incheon, South Korea.

Thus, every step of planning, designing, constructing, testing and operation the facilities should be tailored to obtain the target availability. In particular, integrated optimization of maintenance system at the early planning stage of commercial maglev line construction project can be provided better service than other light rail system and reduce the total maintenance cost in terms of Life Cycle Cost (LCC). The next steps in the program involve the technology development needed to move the project towards a demonstration system.

2 THE NECESSITY AND CONCEPT OF MVMF

2.1 The Necessity of MVMF

For the smooth operation of maglev vehicle, maintaining their good performance is a prerequisite condition. Their functions shall be checked on a cyclic

basis to guarantee their best ability in operation. And also their components and parts should be replaced on time with enough spare parts to keep their normal function. The MVMF should be installed to identify identifies unexpected failures at an early stage and prevents potential accidents and failures.

2.2 The Concept of MVMF

MVMF would be the first structures of the entire commercial maglev line to certify the operation because of the concentrate facilities of operation and maintenance personnel. MVMF will be constructed near by main line, length are 6.113km, and closely are connected with an entrance and exit line.

The necessity of the driverless operation in signaling for all tracks must be defined on the basis of the safety with an operation organization in planning and design phase. Thus we review three ways of adapting range of the driverless operation between main line and MVMF as shown in Table 1.

Table 1. An example of adaptation ways for the range of driverless operation

Classification	Driverless operation range
"A" type	From Main line to all track line in MVMF
"B" type	From Main line to all track line in MVMF except the inspection shed building
"C" type	Main line

There will be installed several structures such as Operating Control Center (OCC), Inspection Shed, Central Operating Office, Substation, warehouse, wastewater treatment equipment. OCC takes charge of monitoring and controlling the mainline operation. Inspection Shed takes charge of maintenance the maglev vehicle. Materials and spare parts are stored in warehouse.

3 OPERATION AND MAINTENANCE PLAN FOR MVMF

3.1 Operation Plan for MVMF

In order to achieve the optimum scale of MVMF, it is necessary to monitor and evaluate the number of operating maglev vehicle. Preferentially 1st phase's operation maglev vehicle will be serviced seven maglev vehicle set and 2nd phase will be added to ten maglev vehicle set as shown in Table 2

Table 2. The number of maglev vehicles during the Operation and maintenance

Classification		1st phase	2nd phase	1st + 2nd phase
		Maglev numbers /year (A)	Maglev numbers/year (c)	A+C
Operation and maintenance maglev vehicle	2013	4 sets	2 sets	6 sets
	2015	1 sets	1 sets	2 sets
	2022	0 sets	7 sets	7 sets
	2032	2 sets	0 sets	2 sets
	Sum	7 sets	10 sets	17 sets

Maglev vehicle set consist of 2 Motorized Car (MC) and levitate 8mm from rail surface in maglev commercial line is shown in Figure 2.

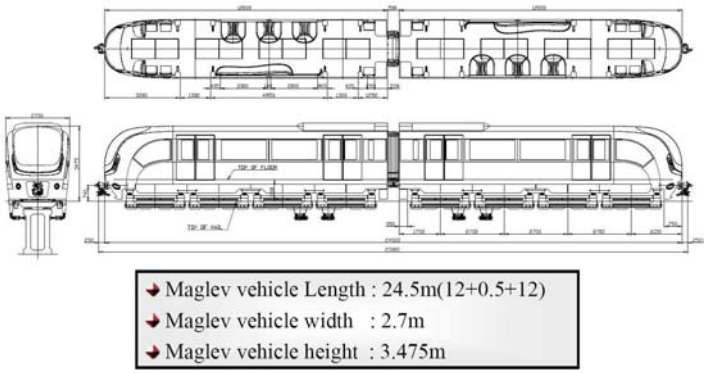

Figure 2. The figures and specification of maglev vehicle

3.2 Maintenance Plan

To maintain Maglev vehicle, MVMF would be prepared the maintenance plan which is composed of maintenance system, structure, equipment, organization, personnel, information management way, etc. Thus our project made the maglev vehicle maintenance plan and major items are like bellows.

- Maintenance system and process plan
- Maintenance facilities and equipment plan
- MMIS development plan
- Maintenance organization and personnel plan
- Education and training course plan

4 OPTIMAL SITE SELECTION FOR MVMF

4.1 Optimal Site Selection Plan

Generally, MVMF site selection depends on its local area characteristic and other special conditions are shown in Table 3. Generally, MVMF are constructed near either the originating station or the termination station to minimize the time needed for maglev vehicle maintenance.

Table 3. MVMF site selecting conditions

MVMF site selecting conditions	· An area is sufficient to secure for MVMF layout · An expansible area in preparation for future increase of maglev vehicle in demands · An area has no limited development district · An area well-situated for the supply of various utilities such as water and drainage, city gas, power supply etc. · An area convenient for staff's commuting

4.2 Entrance and Exit Line Plan

Entrance and Exit Line has plans to single track line and diverged into a turnout of 3-way from the main line considering the number and a velocity of maglev vehicle set.

5 TRACK LAYOUT OF MVMF

To secure smooth movement of maglev vehicle in MVMF, track layout has to be considered with site condition, stabling and maintenance maglev vehicle number, movement flow. Thus, we reviewed two track layout types in our basic design of Maglev Maintenance Facilities Design Project as shown in Figure 3.

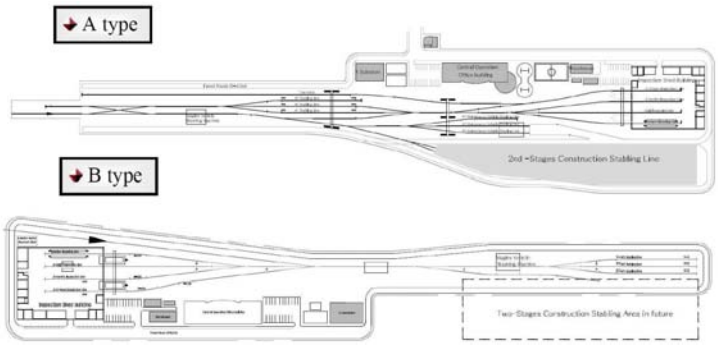

Figure 3. MVMF track layout type

6 MAINTENANCE AND INSPECTION SHED PLAN

6.1 Maintenance Type and Cycle for Maglev Vehicle

In order to estimate the optimum scale of Inspection Shed, it is necessary to know the type and cycle of maglev vehicle maintenance. But we are not received the type and cycle of maintenance from the manufacturing company of maglev vehicle because our design project is going with maglev vehicle development at the same time.

So we adapted the standard specification of light railway vehicle in Korea to determine the type and cycle of maintenance instead of those from the manufacturing company of maglev vehicle as shown in Table 4.

Table 4. Maglev Vehicle Maintenance Type and Cycle

Maintenance Type			Maintenance Cycle
Periodic Inspection	Predeparture and Arrival Inspection		Daily(measurement of consumable parts wear)
	Daily Inspection		Within 3 days
	3months Inspection		Within 3months
	3years Inspection		Within 3years
	6years Inspection		Within 6years
Non-Periodic Inspection	Special Inspection		Occasionally
Vehicle Cleaning	Vehicle Exterior Washing		Daily (It is possible to extend the cycle, depends on the vehicle condition)
	Vehicle Interior Clean-ing	Daily Cleaning	Within Daily
		3Days Cleaning	Within 3days
		1Month Cleaning	Within 1month

6.2 Inspection Shed Plan

Generally, Inspection Shed Building was separated into two workshop, light maintenance workshop and overhaul workshop in heavy railway maintenance facilities. On the other hand, we planned single Inspection Shed Building since the maglev vehicle has shorter length and less maintenance quantity than heavy railway vehicle. In addition we increased outside order for repair and test of each components. Recently other light railway is much alike in building type as shown in Figure 4.

Figure 4. An air view of Inspection Shed Building

Maintenance equipment and facilities should be effectively located in the inside of MVMF. For optimal layout of Inspection Shed, we considered three conditions; 1)first layout of inspection lines according to maintenance type, 2)layout of integrated parts workshop plan with inspection line for efficient maintenance work flow to reduce the time required, 3) separating of office and workshop for instance 1st floor is maglev vehicle body and components workshop, second floor is office and convenient facilities.

Especially, layout of inspection lines which are calculated by maintenance vehicle quantity consisted of 4 tracks, Daily Inspection, 3 Months Inspection, 3 and 6 Years Inspection, and Cleaning track. So we designed a swimming pool pit type inspection track to enhance work efficiency and cleaning line installed inside Inspection Shed to secure staffs safety from bad weather such as a rainy, snowing, hot and cold weather, and Inspection Shed Layout is shown in Figure 5.

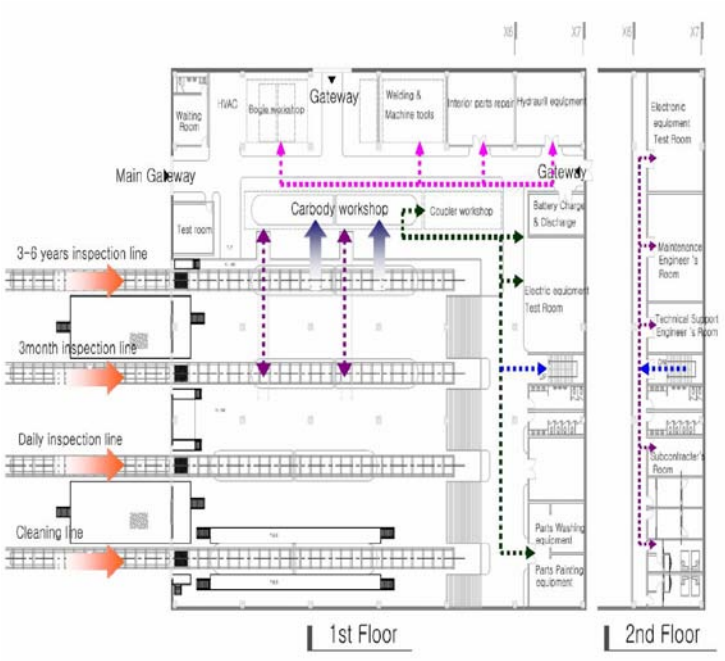

Figure 5. A ground plan of Inspection Shed Building

6.3 Inspection shed Design Criteria

For optimal design of Inspection Shed, we considered several conditions interface with maglev vehicle specification, overhead crane, architecture, logistic equipment as shown in Table 5.

Table 5. Maglev Vehicle Maintenance Type and Cycle

Inspection Shed Building	Width	· It does not interfere with the limit of architecture between inspection line. · Vehicle body workshop have a sufficient area to keep a maglev vehicle set.
	Length	· Inspection line and vehicle body workshop should be long enough for maglev vehicle set · Inspection Shed passage should be long enough for movement of a truck and forklift
	Height	· Vehicle body workshop and 3~6 years inspection line should have enough height to lift maglev vehicle body for assembling or dissembling.

Thus, we made the Inspection Shed Design Criteria. The Inspection Shed should be installed 4 lines with more than 6 to 9 m width between the center of inspection line. Overhead crane installation height is important to estimate the Inspection Shed height. So we decided 8.5m height to lift a maglev vehicle body without damage with the overhead crane in vehicle workshop. Inspection Shed Design Criteria is shown in Figure 6.

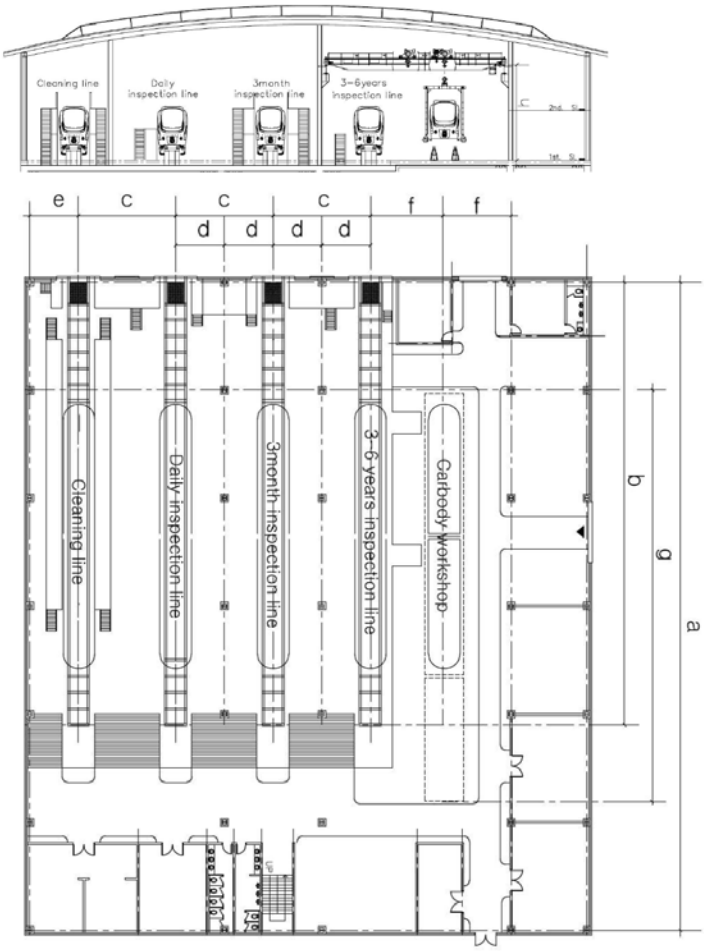

Figure 6. A ground plan of Inspection Shed Design Criteria

Table 6. Design Criteria of Inspection shed

Classification		Design Criteria		Final adaptation
Vehicle Specification	Vehicle Body width	2.7m		2.7m
	Vehicle Length	24.5m		24.5m
Length	Inspection Shed Length	a	-	60m
	Inspection Line Length	b	41m within	41m
Width	A distance between the centre of inspection line	c	6.0~9.0 m	9.0m
	A distance between inspection line and column	d	4.5m over	4.5m
	A distance between inspection line and wall	e	4.5m over	4.5m
Height	Overhead crane installation height	h	8.5~9.0 m	8.5m
Vehicle Body Workshop	Between the centre of vehicle body and column or Between the centre of vehicle body and inspection line	f	6.4m over	6.5m
	workshop length	g	35m over	35m

7 MMIS PLAN

7.1 MMIS Design Plan

MMIS(Maglev Maintenance Information System) is one of the most important tools of maintenance system for staffs to reduce their paper work and efforts in MVMF. MMIS is a knowledge based system which can manage the personnel and resource, maintenance information and records and finally it can reduce the maintenance cost through that management tools as shown in Figure 7.

Figure 7. A definition of MMIS

In addition, MMIS can systematically support maglev vehicle operation and maintenance works to gather maintenance plan and records automatically, supplying status of other system' information via real time interface with inner and outer system.

MMIS consist of 9 Management modules: Vehicle Maintenance, Vehicle, Vehicle Failure, Equipment and Tools, System, Maintenance Cost Control, Maintenance Support, Technical Material, Material and Spare Parts as shown in Figure 8.

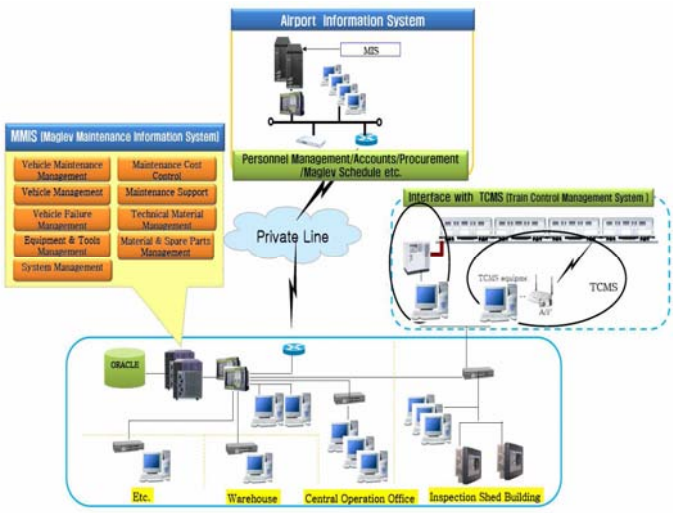

Figure 8. A Concept Diagram of MMIS

7.2 Application of RAM data and RCM for Maglev vehicle Maintenance

Development of MMIS is not only to gain and manage a maintenance records, but also to analyze the maintenance data with Vehicle RAM(Reliability, Availability, Maintainability) data in a cost effective way to adjust the maintenance plan & cycle, working orders. The analysis results of the identified failure modes among maglev vehicles might help to stabilize Preventive Maintenance providing for systematic inspection, correction of incipient failures, modification of Vehicle RAM data either before they occur or before they develop into major defects.

RCM(Reliability Centered Maintenance) refers to a systematic process of preserving system function by selecting and applying effective Preventive Maintenance tasks and analyzing MTBR(Mean Time Between Repair), MTA(Maintenance Task Analysis), and LORA(Level of Repair analysis). Reducing the total Maintenance costs is the final goal of RCM what is associated with system failure and downtime.

Even though RAM & RCM is the most effective ways on the optimal vehicle maintenance, they are not public and settled yet in Korea. In order to employ them in our project, cooperation between the manufacturing company of Maglev Vehicle and Operation Company are needed.

8 CONCLUSIONS

MVMF should be planned to perform the most effective maintenance over a maglev vehicle for normal service through vehicle maintenance works on time. In order to design optimal MVMF, following critical issues are previously reviewed: 1) understanding of site selecting conditions, 2) choosing of the MVMF Layout without unnecessary movements, 3) making of the Maintenance Plan and Inspection Shed Design Criteria, 4) Understanding of the Maglev Vehicle Characteristics, 5) establishment of MMIS development plan.

We have completed the Basic Design of MVMF and have plans to design the Detail Design of MVMF by November 30th, 2008. The Basic Design of MVMF will be possible to change through the Operating Company's requests, during the Detail Design Project. We are occasionally placed in difficult circumstances because we have no experience for MVMF. Otherwise we would make a greater effort to construct a complete MVMF.

9 REFERENCES

1. Ministry of Land, Transport and Maritime Affairs, “The Feasibility Study Report for the Urban Maglev Program”, September, 2006.
2. Korea Rail Network Authority(KRNA), “The Design Project of the Urban Maglev Program – Basic Design Report”, June, 2008