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Railroad Engineering 철도공학

A Study on the Command Priority between Railway Traffic Controllers Based on Railway Control System Using AHP Method

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ABSTRACT

This study compared and analyzed the importance of command priority between railway traffic controllers through pairwise comparison of AHP analysis. 27 railway traffic controllers working on metropolitan railway control center, urban railway control center, and unmanned driving control center responded. As a result of the analysis, all the railway traffic controllers generally recognized the train driving control and train signal control as the most important priorities. For the controller in the manned driving system, a train driving control was the highest at 0.375. On the other hand, the controller based on unmanned driving recognized train signal control as the highest priority at 0.469. In the result of the AHP analysis considering all the variables, the braking system was the highest priority at 0.19 based on manned train driving. On the other hand, the controller based on unmanned train driving recognized wired and wireless network systems and SCADA as the highest priority at 0.267.

Keywords : Manned driving, Unmanned driving, Controller, AHP, Driving trains, Train signal control

1. Introduction

Since the introduction of the railway traffic control license system, the railway traffic controller's work has diversified. In particular, the technological development in terms of interface between the railway system and trains and train control signal systems is improving very quickly. In addition, the birth of a new light railway operation company with the unmanned train driving system is approaching a more important point than ever before. It is not an exaggeration to say that the vitality of railway technology is a train signal system. In general traffic issues, traffic accidents and traffic jams due to signal violations or obstacles have already been proven. The railway transportation sector is no exception. The frequency of large-scale railway accidents caused by signal violations and signal errors is increasing in the history of more than 100 years.

The purpose of this study is how to select railway traffic controllers between their sectors appropriately. To accomplish this, first of all, the command priority between railway traffic controllers has to be identified. Currently, the education and training curriculum in the railway traffic controller license selection occupy a large part of train-related subjects. It is somewhat biased toward the train driving sector. In the train signal sector, the railway traffic controller is biased toward the handling method on the operator's console. Therefore, in the current train control license evaluation process, it is easy to conclude that a train driving controller has an important task to control the trains, and train signal handling is an incidental task. This can be a subject of the train control education and training process that limits the scope of railway traffic controller to only

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trains. Nowadays, unmanned driving-based train control work is increasing for new railway lines. This means that train signal sector is getting important than ever before.

This study examines the priorities of each train controller section in terms of knowledge and technology to command trains between manned and unmanned driving-based controllers. And, it is intended to compare the system priorities in commanding the control system between manned and unmanned driving-based controllers. In addition, it is proposed to systematically improve the contents of the subject that require detailed train controller education, such as understanding train breaks, interlocking control device principles which are important for train safety in handling signals.

2. Research Method

This study conducted a group survey of AHP experts targeting 27 railway traffic controllers, including metropolitan train control, urban railway train control, unmanned train driving control, and other train control experts. AHP hierarchy was classified into two levels as shown in Fig. 1. First level has five different variables. They are a railway train control sector, a railway signal sector, a railway electric sector, a railway information & communication sector, and a railway mechanical sector. Second level has a total of 16 variables. A railway train sector has door, brake devices, and driving devices. A railway signal control sector has TTC, wayside ATC system, cab signaling system, ground signal facility. An railway electric power section has SCADA, substation, and overhead contact line. A railway information & communication sector has a wired/wireless network, transmission of information, and information facilities. A railway mechanical sector has PSD, escalator/elevator, and air-conditioning equipment.

Through this AHP analysis, the priority of importance by sector was derived from the variables in two levels. In addition, the consistency index (CI) was calculated for the reliability of the AHP expert group survey.

3. Results of the Study

All the variables necessary for railway remote control handling and communication information between sites on commanding the train of controllers was divided into two levels. In addition, the model was applied to the variables which were important for train operation relatively, targeting the priority data of importance by train control sectors. As a result of the analysis, first of all, the relative important priorities of controllers by railway sector were shown in Fig. 2. As a result of the application, overall, the train driving

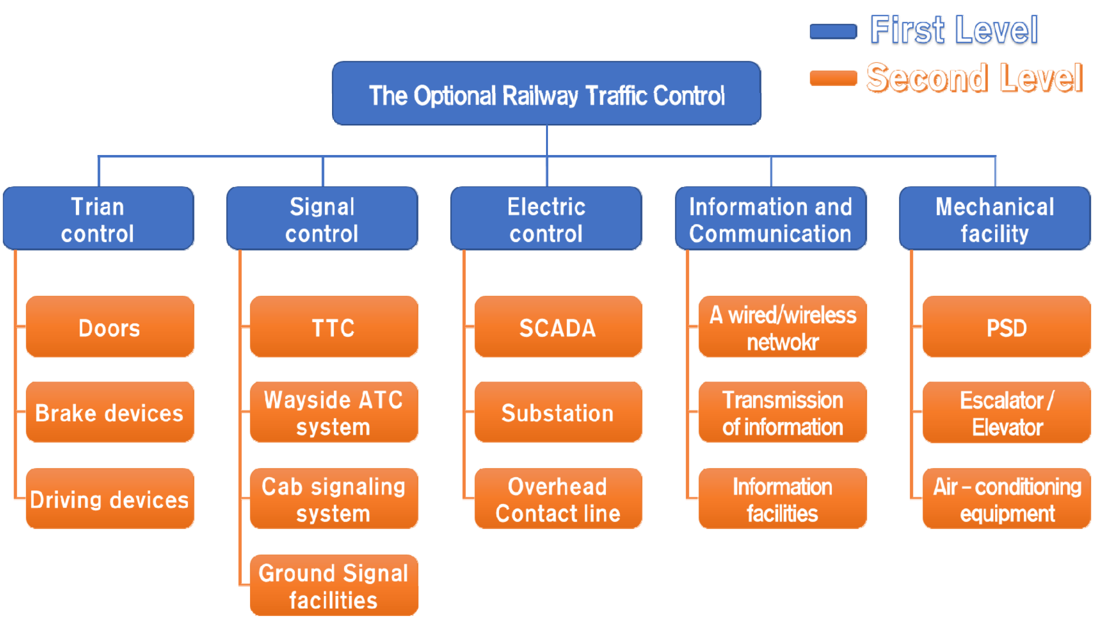

Fig. 1. A Hierarchy Diagram for AHP Analysis

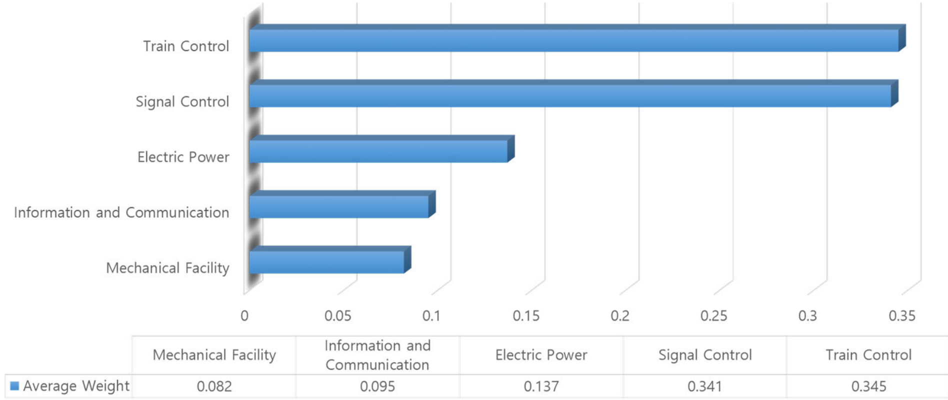

Fig. 2. Relative Important Priorities of Train Controllers in Railway Control System

train and train signal control sectors were selected as the most important priorities. Among them, it can be seen that the preference of the driving train is a little bit higher with a difference of 0.004.

The importance of priority by sectors in terms of handling and technical knowledge on controlling trains between manned

Table 1. Comparison of Priorities between Railway Manned and Unmanned Train Driving

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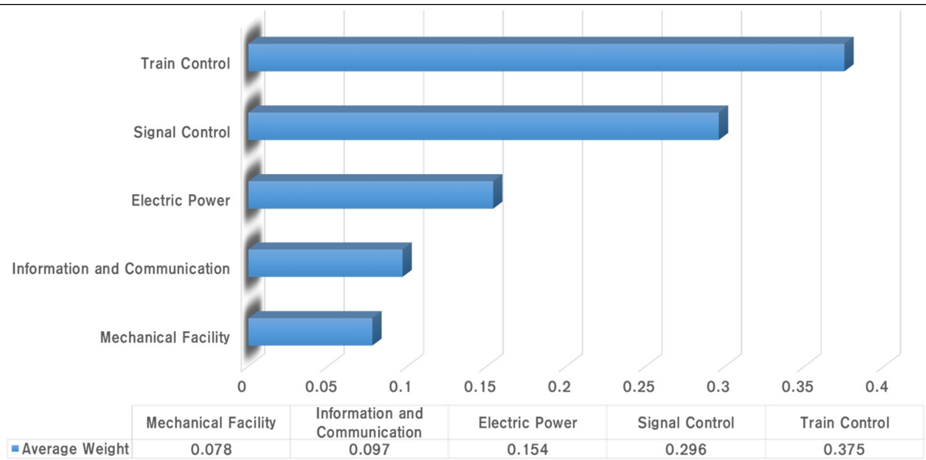
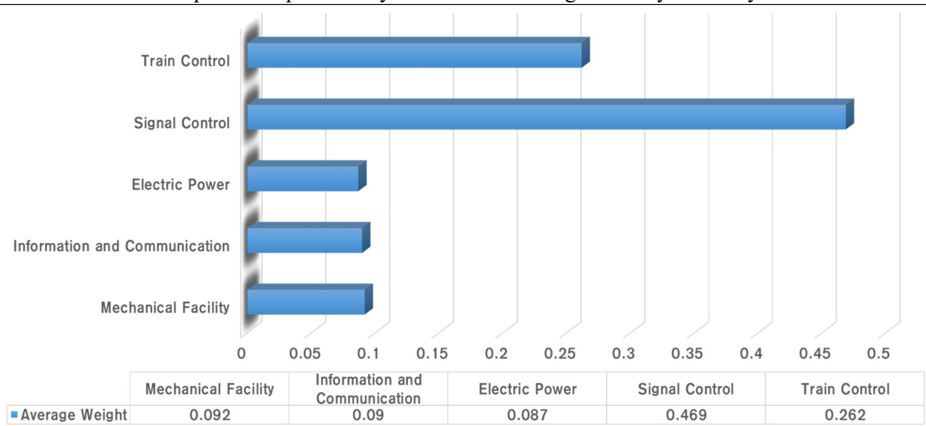
<tr><td>(a)</td><td>

※Comparison of priorities by manned train driving in railway control system</td></tr>
<tr><td>(b)</td><td>

※Comparison of priorities by unmanned train driving in railway control system</td></tr>
</table>

Table 2. Relative Priorities of Train Controllers between Railway Manned and Unmanned Train Driving in Railway Control System

Average Weight						CI
First Level	Second Level	Manned	Priority	Unmanned	Priority	
Train control	Doors	0.205	3	0.329	2	0.01
	Brake device	0.510	1	0.455	1	
	Driving device	0.284	2	0.215	3	
Signal control	TTC	0.491	1	0.309	2	0.02
	Wayside ATC system	0.180	2	0.309	1	
	Cab signaling system	0.180	2	0.209	3	
	Ground signal system	0.149	4	0.150	4	
Electric power	SCADA	0.600	1	0.570	1	0.01
	Substation	0.240	2	0.183	3	
	Overhead contact line	0.160	3	0.247	2	
Information and Communication	A wired/wireless network	0.392	1	0.570	1	0.01
	Transmission of information	0.240	2	0.183	3	
	Information facilities	0.160	3	0.247	2	
Mechanical facility	PSD	0.696	1	0.640	1	0.01
	Escalator/Elevator	0.137	3	0.169	3	
	Air-conditioning equipment	0.167	2	0.192	2	

and unmanned driving-based systems was identified through AHP analysis. As a result of the analysis, the relative importance priority of railway train controllers by railway traffic sectors was shown in Table 1 and 2.

As a result of the application, the train controller based on manned train driving had the highest priority of train control sector at 0.375, followed by railway train signal control (0.296). The electric power of the subway (0.154), information and communication (0.097), and mechanical equipment (0.078) were followed. The railway train controller based on unmanned train driving recognized railway traffic signal control sector as the highest priority at 0.469, followed by the driving vehicle (0.262). Next, it was seen that the mechanical equipment (0.092), the information and communication (0.090), and the electric power of the subway (0.087) were in order. There was a meaningful difference in the importance between controllers due to the difference in the characteristics and scope of work between manned and unmanned driving systems.

As shown in Table ‘2’ through ‘5’, the overall ranking of train controllers based on the railway control system was derived in a way that considers the first and second level weights, respectively. As a result of the application, train controllers based on manned train driving generally had the highest weighting degree in the priority of driving trains. In particular, braking system was 0.19, which was the highest priority among systems and devices. After that, TTC was 0.145, followed by propulsion system 0.107. Subsequently, SCADA, which was the electric power sector, ranked 0.092, followed by the entrance door in fifth place, accounting for 0.077. And PSD was followed by 0.054, and the ground device and the vehicle listing value were the same in seventh place. Next, the signal facilities in the track were 0.044, the wired and wireless networks in the information and communication sector were 0.038, the substation is 11th with 0.037, the processing front lane was 0.025, and the information transmission device in the information and communication section was 13th, ranking 14th with 016 and air conditioning facilities and elevators were the lowest at 0.013 and 0.011.

On the other hand, in the case of unmanned train driving controllers, as shown in Table 5, the highest ranking was 0.267 for wired and wireless network systems in the information and communication sector and SCADA in the electric power sector, followed by TTC facilities as the third place tied with ground devices in the signal control field, which was 0.145. Next, it was 0.119 for braking, 6th for information facilities and processing lanes, and 0.116 for a tie. And in the 8th

Table 3. Overall Priorities among Variables for Commanding Controllers

Sortation	Areas of control based manned operation					Areas of control based unmanned operation			
Train control	0.375	Doors	0.077	0.205	3	0.086	0.329	2	0.262
		Brake device	0.191	0.510	1	0.119	0.455	1	
		Driving device	0.107	0.284	2	0.056	0.215	3	
Signal control	0.296	TTC	0.145	0.491	1	0.145	0.309	2	0.469
		Wayside ATC system	0.053	0.180	2	0.145	0.309	1	
		Cab signaling system	0.053	0.180	2	0.098	0.209	3	
		Ground signal system	0.044	0.149	4	0.070	0.150	4	
Electric power	0.154	SCADA	0.092	0.600	1	0.267	0.57	1	0.087
		Substation	0.037	0.240	2	0.086	0.183	3	
		Overhead contact line	0.025	0.160	3	0.116	0.247	2	
Information and communication	0.097	A wired/wireless network	0.038	0.392	1	0.267	0.570	1	0.09
		Transmission of information	0.023	0.240	2	0.086	0.183	3	
		Information facilities	0.016	0.160	3	0.116	0.247	2	
Mechanical equiment	0.078	PSD	0.054	0.696	1	0.059	0.640	1	0.092
		Escalator/Elevator	0.011	0.137	3	0.016	0.169	3	
		Air-conditioning equipment	0.013	0.167	2	0.018	0.192	2	

Table 4. Overall Priorities among Areas for Controllers by Manned Train Driving

Manned operation		
Average weight	Priority	Areas of control
0.191	1	Brake
0.145	2	TTC
0.107	3	Driving
0.092	4	SCADA
0.077	5	Doors
0.054	6	PSD
0.053	7	Wayside ATC
0.053	7	Cab signaling
0.044	9	Ground signal
0.038	10	A wired/wireless
0.037	11	Substaion
0.025	12	Overhead contact line
0.023	13	Information of transmission
0.016	14	Information facilities
0.013	15	Air-conditioning equipment
0.011	16	Escalator/Elevator

Table 5. Overall Priorities among Areas for Controllers by Unmanned Train Driving

Unmanned driving		
Average weight	Priority	Areas of control
0.267	1	A wired/wireless network
0.267	1	SCADA
0.145	3	TTC
0.145	3	Wayside ATC system
0.119	5	Brake devices
0.116	6	Information facilities
0.116	6	Overhead contact line
0.098	8	Cab signaling
0.086	10	Information of transmission
0.086	10	Substaion
0.086	10	Doors
0.070	12	Ground signal
0.059	13	PSD
0.056	14	Driving devices
0.018	15	Air-conditioning equipment
0.016	16	Escalator/Elevator

place, the vehicle listing value was 0.098, followed by information transmission, the next sector of information and communication, tied for 10th along with substations and doors. Subsequently, the train signal equipment on the track was 0.070, followed by PSD in the 13th place, and the propulsion system was 0.056 and air conditioning facilities and elevators accounted for the lowest weight at 0.018 and 0.016, respectively. The consistency index of AHP analysis of unmanned train driving controllers was 0.01.

4. Conclusion

In this study, the command priority between railway traffic command sectors was compared and analyzed through pairwise comparison of AHP analysis in terms of handling and technical knowledge on commanding trains between manned and unmanned train driving controllers in the railway sectors. As a result of the analysis, it was found that manned and unmanned train driving produced meaningful results in a significant difference in the relative importance priority map of controllers by railway sectors. First of all, the analysis of all train traffic controllers showed that train driving and signal control sectors were generally recognized as the most important priorities. Among them, the preference of train driving was slightly higher with a difference of 0.004. However, in the comparative analysis of the importance of the major priority classification by sector in terms of handling and technical knowledge between manned and unmanned train driving controllers, the priority of the driver's train was the highest at 0.375, followed by the signal control (0.296). On the other hand, the railway traffic controller based on unmanned train driving recognized train signal control as the highest priority at 0.469, followed by the driving vehicle (0.262).

In the comparative analysis of the importance considering both the first level and second categories to determine the overall weight priority, it was found that there were many differences in the priorities between the two groups. In other words, the train controller based on manned train driving generally placed the highest priority of driving trains, so the braking system was the highest among systems and devices at 0.19.

In contrast, in the case of unmanned train driving controllers, as already mentioned, wired and wireless network systems in the information and communication sector and SCADA in the electric power sector were selected as the highest priority at 0.267. In the case of TTC, both groups were similarly weighted higher as second and third, respectively. To interpret the meaning of this difference, in the case of a train controller based on unmanned train driving, the train controller commands the train and signal through more remote control than the manned train driving.

This procedure made the weight of wired/wireless networks and power SCADA, which were the core of full-scale control, high in priority. In the case of unmanned train driving controllers in Korea, most of them are light railway systems, except for the Shinbundang line. In the case of manned driving-based tram lines, rather complex systems were generally intertwined with processing catenary techniques in the air, while light railway controllers handle more SCADA remote control than manned driving-based ones. This was interpreted as having a higher weight than SCADA of manned driving.

In addition, unlike manned train driving systems, unmanned train driving controllers naturally focused on signal control devices, especially ground devices that rely on the importance of the interface between site and control rather than vehicle-listed devices. This means a markedly different result from the priority of manned train driving controllers. In the case of the manned train driving controller, the priority of the driving train was given a high weight, which requires control and monitoring of train operation that changes from moment to moment in terms of the driving controller who communicates with the train engineer. The judgment of train operation was made through wireless communication with the train engineer. Since the train was controlled in this way, it was understood that the weight was relatively given to the driving train rather than signal control.

This study started with the aim of being a competent selection of appropriate railway traffic controllers by substantially strengthening education in terms of railway signals. To accomplish this, first of all, the priorities of the knowledge and technical fields of the railway traffic controller, which are urgently needed for train control regarding the field equipment, were identified based on the equipment of each control sector and its interface.

In consideration of the recent increase in unmanned train driving control tasks, meaningful results were derived by comparing the system priorities on controlling the railway train control system and field equipment between manned and unmanned driving-based controllers. Based on the results of this study, it was proposed to closely review the characteristics of work between manned and unmanned train driving controllers in the future and to slightly reduce the content bias of the curriculum of somewhat biased railway driving trains. On the other hand, it was possible to strengthen system understanding and training subjects related to the sector of signal and communication in a situation where the importance division between the two control tasks was ambiguous and insufficient in line with clear differences in work. In particular, it was expected that the railway train control license evaluation system and educational subject content would be improved in the direction of adding and strengthening the understanding and linkage principle of railway signals and the related interface-based reasonable and balanced contents so that controllers can realistically help handle railway signals.

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