Considerations for a Next-generation Railway System in the Tokyo Metropolitan Area

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In studies for the next-generation railway system in the Tokyo metropolitan area, we proceeded with evaluation in total of different train operation systems that had been independently developed in the past. In this article, we will introduce the procedures and framework for a rough study of the systems that we tried in such an evaluation process. We worked on the study without being bound by constraints such as current technical level, organization and rules. The greatest feature of these considerations is the shift from the previous technology-oriented approach to a needs-oriented approach where we started from the ideal railway system.

The procedures and framework of the study approach are still being developed. The ideal situation after 10 years (target level) may need review. To gain consistency between the system equipment upgrade policy and items such as the development schedule, directionality and target level, it is crucial for us to continuously execute and repeat the study process.

Keywords: Tokyo metropolitan area, Railway system, Needs-oriented

1 Introduction

Train operation is a large-scale system using rolling stock, wayside equipment and a large staff including crews and inspection and repair personnel. In the Tokyo metropolitan area in particular, a huge number of trains have to be operated on many lines. Train operation modes have thus become complex for shorter travel time and increased convenience. This is achieved by means including setting of many types of trains such as rapid service and expanding through service. In order to support such massive and complex train operation in the Tokyo metropolitan area, a variety of systems in the fields of transportation, signals and rolling stock have been developed.

Each system has developed introducing technologies of the times while dealing with policies according to the needs of the time. And partly due to the different timing of replacement of the systems, they have evolved individually while keeping linkages with each other.

With the recent remarkable advance of ICT, faster processing and greater information transmission capacity at faster speeds has increased the amount of information that the systems handle and transmit to each other. That has gradually strengthened the linkage between the systems. Thus, we have also come to need to study systems in a broader range that had hitherto been discussed separately for the most part. In this article, we will introduce our attempts at a structure to study systems related to train operation with a comprehensive view.

2 Issues in Current System Building

2.1 Issues in Studies of Individual Systems

Current JR East systems for train operation in the Tokyo metropolitan area include systems related to transport management and route control such as the Autonomous Decentralized Transport Operation Control System (ATOS), systems related to train control such as Digital ATC (D-ATC) and the Train Information Management System (TIMS) related to vehicle monitoring. We are further proceeding with development such as that for deploying the Advanced Train Administration and Communications System using radio communication (ATACS) in the Tokyo metropolitan area and development of a next-generation vehicle monitoring system.

As previously mentioned, individual systems have been independently and separately studied and developed up to now. Particularly, linkage between vehicle (onboard) systems and wayside systems was limited since there were few options in data transmission methods and the amount of transmittable data was small.

Problems (disadvantages) of separate study of individual systems could include the following.

For more detail, please refer to the full text of the article.
Lack of viewing the system in total

1) It is difficult to comprehend the overall picture since people look at connections only with other systems.

2) System features and aims are not shared.

3) With separate studies, the total system is not always consistent or includes waste and inefficiency even if systems may work rationally within their own scopes. There might be cases where possession and processing of the data is duplicated. For example, the same data may be compiled and stored at multiple locations, and different systems may do similar processing.

Lack of consistency and coordination between update policy and development of equipment and rolling stock

Update periods of wayside systems and rolling stock are different, so updating is not always done at the same time even on the same line. As the wayside system and the rolling stock system are studied independently, it is difficult to make them consistent and linked in terms of directionality, target level etc. on the same line due to the schedule difference. That might cause additional work such as modification for new linkage to other systems just after the facility renewal, functional restrictions and inconsistency.

Or, if the departments involved in development are not aware of the implementation schedule for facility renewal etc., it will cause waste due to the difference in timing. For example, functional development may not be done in time of the update. Conversely, the development results may not be immediately utilized.

It is difficult to break such a cycle of unfavorable incidents with independent studies.

2.2 Providing a Platform to Consider Systems as a Whole

In order to eliminate the aforementioned disadvantages, we proposed having meetings where we study the transport management system, vehicle monitoring system and train control system together (Fig. 2). Such study meetings have the following two roles.

1) Providing a platform to consider the system as a whole
   This will be a platform where people concerned consider and share the ideal system for the overall system that cannot be done in individual system studies.

2) Providing a platform to consider linking policies
   Here we mean checking and coordinating the consistency and linkage of each system with the overall picture in terms of their directionality and target level.

This platform will also play an important role in making development timing of each system appropriate while keeping the system update schedule in mind. We aim to make the meeting a well-functioning platform where we can eliminate additional work as much as possible and create a harmonized and unified system.

3 Needs-oriented Studies Approach

In past studies, we often made considerations assuming constraints such as current technical level, organization and rules. Such an approach assumes current technology easily leads to a mindset that such technology can bring about certain functions. This will not completely overcome the current constraints, duplications or inefficiencies. Without consideration of future continuation, the solution will soon become obsolete and unable to handle technological advances or heightened needs, even if current issues at hand may be solved.

Thus, we studied a needs-oriented approach as an approach for sustainable studies where we study the ideal system without being too tightly bound by current situations. This replaces the past approach that was rather technology-oriented (Fig. 3).

We explain the process of seeking the ideal system and goals through this approach as follows.

3.1 Aim and Scope of Consideration for the System

With the next-generation railway system in the Tokyo metropolitan area, we will aim for "safety improvement", "(transport) resilience improvement", "(transport) flexibility improvement", "reduction of environmental burden" and "low costs" by fully utilizing ICT and optimizing wayside- and onboard systems (Fig. 4). We must eliminate duplications and inefficiencies of the systems that developed independently by building an information network with ICT and reallocating functions with a focus on the information flow.
Objective of Next-generation Railway System

- Optimize wayside—onboard systems to achieve ideal system
  - Safety improvement
  - Resilience improvement
  - Flexibility improvement
  - Reduction of environmental burden
  - Low costs

3.2 Setting Target Levels

For the five objectives of “safety improvement”, “(transport) resilience improvement”, “(transport) flexibility improvement”, “reduction of environmental burden” and “low costs” (Fig. 6), we studied the setting of target levels.

As some of the targets are not easily expressed in numerical values, we decided to set non-numerical targets. With the linguistic description of the future state (the ideal state) and the current state, we set the intermediate state between ideal and current as the target level to reach. Some of the details considered for flexibility are shown in Fig. 7.

For each of the five goals, we made out a description of the target level.

3.3 Selection and Allocation of Functions to Achieve Target State

For each target state item, we arrange the definition and overview of the functions and input information required and output information (Fig. 8).

Next, we allocate those on the information network. Attention is paid there to inflow and outflow of the information, similarity of the functions and location where functions are deployed (onboard, dispatcher’s office, depot). Then, we review the allocation of the functions and consider the merger or separation of functions while taking into account the information flow. In this way, we roughly assign the functions (Fig. 9).

Next, functional allocation is corrected based on items including consideration of the amount of information, cost, update period of the information and credibility of the required information. We have proposed a procedure to consider the method to achieve the functions and to edit technical issues in steps while considering items such as achievable technical levels. This study procedure is utilized simply for rough study of the overall functional allocation, and more detailed study will be required in developing individual systems. The reason for this is that the order of the jobs (processing) is not necessarily reflected by the simple inflow/outflow of the information alone.
(2) Continuing to consider linking policies

Consideration on linking policies that checks and coordinates consistency with the overall system and linkage with other individual systems in terms of items such as directionality and target levels also has to be a continuous and periodical effort.

Consideration on linking policies has to be periodically checked and corrected to reflect changes to the policy schedule of system updates etc., and to correct the development timing since that schedule can change.

5 Conclusion

We proposed a process for studying a next-generation railway system in the Tokyo metropolitan area and methods for studying a structure making that a continuous effort. A feature of the improvement efforts is a shift from past technology-oriented approach to a needs-oriented approach.

As description of the state of the ideal system and the target levels is difficult to directly express as technological needs, such description will remain simply as a concept. But we believe that continuing to study items such as setting common goals and steering of policies for the railway system in the Tokyo metropolitan area as a collective of multiple systems are useful for optimizing the system as a whole and making it closer to the ideal.

We will continue to consider the new system by this needs-oriented approach while improving the study procedure.

Reference: